Rotunda Hospital Dublin - BMS Upgrade

Mechanical and Public Health Services' Specification

Mechanical Specification **Section B: Systems Description – Building Energy Management System (BEMS)**

14.05.26

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1 General

1.1 Introduction

A. This specification covers the design, supply, installation and commissioning of the upgrade of the BEMS and automatic controls installation for the mechanical and electrical engineering services at Rotunda Hospital Dublin.

B. The existing BMS system within the hospital is at the end of its useful life and is to be subject to a complete upgrade.

C. This upgrade project represents the first phase in a multi-year programme to establish a campus wide BMS platform across Rotunda Hospital. The current scope focuses on critical infrastructure in existing departments, including the Theatre, Delivery Suite and NICU, with the express intent that the upgraded system can be seamlessly scaled and integrated with future developments.

D. A major new build is planned for 2029, which will house critical hospital infrastructure and include a BMS installation. As such, the upgraded BMS must be interoperable and interface-ready with the BMS solution to be delivered as part of the 2029 development (the “CCW BMS”).

E. The upgraded system must, therefore, be scalable, future-proof, and designed with long-term integration and expansion in mind. The contractor must ensure that all components, software, and infrastructure installed now can serve as a foundation for future phases, minimizing disruption, duplication of effort, or costly retrofits in the next five years. The methodology for future expansion is to be set out in writing to the client and design team.

F. The contractor selected for this project will be responsible for performing a thorough site survey to assess the condition of the existing system, identify necessary upgrades, and provide a detailed pricing proposal based on the assessment. A survey of the existing system including a points list, screen shots and photographs has been included within the tender documentation for information only. This information is to be considered indicative. The appointed contractor will be required to complete their own extensive survey of the hospital BMS system to identify the upgrade works required which will inform the design of the proposed system.

G. Key deliverables of the project will include the installation of upgraded equipment and field devices, integration of communication networks, energy monitoring enhancements, and full system commissioning. The contractor will also be tasked with conducting functional and performance testing to ensure seamless integration with existing hospital systems, including HVAC, lighting, energy meters, and emergency generator controls.

H. The successful contractor will be required to meet all relevant industry and safety standards, regulations, and best practices throughout the execution of the project, and provide all

necessary documentation for the BMS system, including system schematics, configuration settings, and operation manuals.

I. This upgrade will enhance the operational efficiency, sustainability, and reliability of the BMS, supporting the hospital's ongoing commitment to providing a safe and comfortable environment for patients, staff, and visitors.

J. The BEMS Specialist Contractor will be permitted to retain and reuse existing controllers / services where practical and feasible. The retention of any services must be agreed in writing in advance of the upgrade works with the client and design team.

K. The BEMS system is to be by Siemens, Honeywell or an equal and approved system.

L. The ICT network supporting the BEMS system must be standalone. No connection will be permitted to the HSE ICT network. The system must provide remote access capability to the Estates team. Critical alarms shall also be communicated to the estates team via email and text message. The BEMS contractor will be responsible for providing the standalone ICT network.

M. The BEMS contractor will be the main contractor responsible for providing all works required for the upgrade works including any builderswork, mechanical and electrical works required to complete the upgrade. This includes the modification of existing services and installation of new field devices, dampers, pockets, sensors, meters and valves etc. required to control and monitor the existing plant.

N. The only exception to the above will be the provision of fire stopping. The hospital will ensure fire stopping is provided by a separate specialist. The BEMS contractor will be required to identify areas requiring fire stopping and provide a set of drawings identifying where opes will be formed in advance of the completion of any works. All fire stopping details are to be agreed with the fire stopping contractor in advance of any installation works.

O. All tendering contractors must attend site for a site inspection as part of the tender process. Any tendering contractors that fail to do so will be excluded from tendering.

P. The BEMS Specialist Contractor must demonstrate previous experience within a critical healthcare environment and working in a live environment. The existing BEMS and M&E systems must be maintained live through the duration of the BEMS upgrade works. Out of hours works are to be included as required to achieve this.

Q. The key functions of the BMS that require assessment, repair, and/or upgrade include but are not limited to the following equipment below with their associated systems:

- Control and monitoring of hot water boilers.
- Control and monitoring of hot water services.
- Control of pump sets.
- Monitoring of gas and electric meters.
- Control and monitoring of air handling units (AHUs).
- Control and monitoring of fans.
- Control and monitoring of DX units.
- Integration with control panels in the theatre.
- Integration with generator controls.
- Control and monitoring of lighting systems.

R. Each of these functions is critical for maintaining the proper operation of the Theatre, Delivery Suite, and NICU departments, which are high-priority areas requiring precise environmental control.

1.2 BEMS Contractor Requirements

A. The BEMS Specialist Contractor/specialist shall provide a complete BEMS (Building Energy Management System) and Controls installation to satisfy the automatic control requirements of the building including heating, cooling, air conditioning and ventilation systems. BEMS Specialist Contractor shall design the Building Energy Management System and associated automatic controls to operate satisfactorily in accordance with the specification and drawings.

B. The Building Energy Management System shall be the current range of the intelligent controllers fully compliant with ISO 16484-5 / BACnet protocol utilising BACnet/IP and MS-TP communications.

C. The BEMS supplied shall meet the latest version of ISO 16484 Part 5 & 6 Building Automation and control systems (BACS).

D. The BEMS Specialist Contractor shall be an approved system integrator fully backed by the controls manufacturer.

E. The Building Energy Management System package shall include for all controls, control components, energy management hardware and software programmes, motor control panels and intelligent outstation components, distributed control panels and associated wiring.

F. The BEMS shall form the principal part of the HVAC systems control and energy monitoring for the building. The energy monitoring features will include:

a. Monitoring utility consumption;

b. Monitoring overall energy usage against targets;

c. Energy reporting for Facilities Management, Principals and Heads of Department;

d. Energy target exceedance and alarms;

e. Trend logging of environmental conditions;

f. Customisable dashboard for individual users;

g. Cloud based data storage and retrieval;

h. Smart technology and wireless connectivity.

G. Any point on the BEMS achieved through integration shall have the same features of a hard point and shall be logged, displayed, graphed, have set points and alarms etc. as though it where wired to hard BEMS point.

H. BEMS Specialist Contractor shall ensure that the system has sufficient capacity to cater for all points from all systems including any necessary hardware, gateways, software, dongles, licences, memory capacity, network and communications capacity, server grade PC with capacity to effect a functional, fast and responsive system. Networks shall not be overloaded to reduce hardware costs at the expense of performance.

I. The BEMS Software shall be web server based allowing unlimited concurrent users access the BEMS via intranet/internet/web. This is on top of the full BEMS user and engineering software which can be customised to meet the needs of the end user.

J. BEMS Specialist Contractor shall allow suitable attendances for the creation and implementation of a BEMS VLAN (Virtual Local Area Network) including all necessary repeat visits and retesting and commissioning.

K. The Contractor during tender stage and throughout the project shall ensure that there are no scope gaps with the integration of systems and that a coordinated and fully comprehensive solution is delivered. There shall be no gaps in demarcation (for instance on a KNX network who supplies the KNX network sundries or write the group addresses for BEMS integration).

L. The BEMS Specialist Contractor shall ensure that integration protocols chosen allow the required points to be transmitted in each direction.

1.3 Phasing & Hospital Constraints

A. All works shall be carried out with minimal disruption to hospital operations. The contractor must coordinate with hospital engineering and clinical staff to develop a phased installation plan. This may include:

- Night or weekend work in critical areas (e.g., NICU, Theatre);
- One system or zone being upgraded at a time;
- Detailed temporary control strategies during system switchover;
- Permit-to-work, infection control, or isolation procedure;
- Where legacy systems are still in use, transition plans must be submitted and agreed with hospital facilities teams.

1.4 Information Security Specification

A. The proposed solution must preserve the confidentiality, integrity, and availability of information, services, and applications. The proposed solution must conform to all of the Client's Information Security Policies. The selected contractor shall coordinate with the Rotunda Hospital IT department for the following policies:

- Network Security Policy;
- Physical Security Policy;
- Logging and Monitoring Policy;
- Password Policy;
- Third Party Management Policy;
- Identity and Access Management Policy;
- Malware and Antivirus Policy.

1.5 Scope of Works

A. The proposed control requirements for the Heating, Ventilation and Air Conditioning (HVAC) systems shall include, but not be limited to:

   a. Provision of communications networks to each Motor Control Centre (MCC) including network interface units;

   b. All air handling units and associated Motor Control Centres;

   c. Kitchen ventilation system plant integration, operation and control;

   d. Chiller and boiler plant control and sequencing;

   e. Temperature and humidity control and CO_2 monitoring;

   f. All primary, secondary and tertiary circulation pumps;

   g. All extract fans, including smoke extract systems;

   h. DHWS control, including HWS temperature monitoring at point of generation;

   i. Central water storage volume and temperature monitoring;

   j. Central and service fuel oil tank storage volume monitoring and controls;

   k. Provision of weather stations including air temperature, wind speed, wind direction, relative humidity, barometric pressure and rainfall;

   l. Associated instrumentation, control wiring, power feeds, power to variable speed drives and motors.

   m. Interface to other systems including:

      i. Utility meters;

      ii. Hot water generation;

      iii. Entrance foyer air curtains;

      iv. Carpark general ventilation and smoke extract system;

      v. Fire suppression systems;

      vi. Intelligent lighting control systems;

      vii. Occupancy detection systems;

      viii. Kitchen canopies;

B. The Controls shall be carried out in accordance with National Rules for Electrical Installations IS 10101:2020 requirements for Electrical Installations, the appropriate British Standards and Codes of Practice and the requirements contained in IEE Guidance Notes.

C. In addition to the appropriate Irish Standards and Codes of Practice, BEMS Specialist Contractor must have an established track record in the successful completion of projects of similar size and complexity.

D. BEMS Specialist Contractor shall be responsible for the design development, selection of components, co-ordination including sizing all control cable as required for his field equipment. BEMS Specialist Contractor shall be responsible for supply, installation, testing, commissioning and handing over to the satisfaction of the Employer's Representative, the complete automatic controls and monitoring installations associated with the descriptions of operation and points schedules detailed within this specification and drawings including:

   a. Centralised Building Energy Management System including associated network Ethernet communications between each of the control panels;

b. All standard and custom software together with its specific configuration to meet the project requirements;

c. Communication with other control and monitoring systems including communication to remote outstations in external compounds such as the generators, oil tanks and rain water harvesting tanks;

d. Control panels incorporating BEMS controllers distributed around the Building;

e. Variable speed drives (VSD's) and associated supporting framework. For all air handling units and circulators.

f. All field mounted control devices associated with the automatic controls installation including valves, actuators, damper actuators, sensors, switches, etc.

g. All data communication systems;

h. Magnahelic differential pressure gauges and air differential pressure on all air handling plant and fans. The BEMS Specialist Contractor shall provide all LV field cables, associated trays, conduit, flexible conduit, flexible pneumatic sheathing for the differential pressure switch tapings and final outlet boxes;

i. Operating and maintenance manuals, digital safety file, as-installed drawings. Client training on-site and off-site.

j. Seasonal commissioning.

E. The contractor will be responsible for all associated electrical works. The works carried out by the Electrical Contractor under the supervision of the BEMS Specialist Contractor shall include:

a. All controls wiring between plant items/field devices and control panels including associated trays, trunking, conduit, flexible conduit, final outlet boxes and all containment systems. Final controls wiring type cores, e.g. Belden or screened etc. and cables selections shall be confirmed by the BEMS Specialist Contractor and submitted for comment prior to manufacture and commissioning by the BEMS Specialist Contractor.

b. All power wiring between plant items, control panels and variable speed drives as indicated on the control panel schedules including associated trays, trunking, conduit, flexible conduit, flexible sheathing etc., final outlet boxes and all containment systems. Rating shown on the MCC schedules are for tender purposes only. Electrical Contractor shall confirm all final plant power (kW) ratings to suit final plant selections and associated cable sizes prior to manufacture /installation. Final cable size shall be submitted to the Engineer for comment by the Electrical Contractor.

F. Electrical Contractor shall include all controls within the primary containment and shall provide all additional secondary containment required for the control and power installation to all items of plant. All BEMS cabling and LV cabling between control panels and HVAC plant and equipment including ‘package plant’ shall be provided and installed by the Electrical Contractor.

G. Electrical contractor shall include for new containment systems as required on robust galvanised steel tray support tray and trunking including segregation of LV, ELV and communications cabling.

1.6 Existing Building Services' Installations

A. The Controls Specialist Contractor shall include in full for the strip out of all redundant services. The contractor must include for the disposal from site of all waste. No redundant services shall be permitted to remain in place. All services to be disconnected at the main, no dead legs shall be left within the system.

B. Prior to the commencement of works the contractor shall survey the existing mechanical services and confirm their satisfaction with the condition and operation of any systems to be modified as part of the works.

C. The contractor is to include for all survey work/finger printing necessary as part of the works. No additional costs will be entertained for failure to understand the existing services installation.

D. The contractor is to include for all survey work/finger printing necessary as part of the works. No additional costs will be entertained for failure to understand the existing services installation.

1.7 Contractor Design Responsibility

A. The following systems require contractor design responsibility and associated PI insurance;

a. Mechanical Contractor – anchors / bracketing / supports.

b. Controls and Building BEMS including control / ELV cable selection.

c. Final circuit configuration and earthing.

1.8 Construction Product Specification

A. From July 2013 CE marking of construction products covered by harmonised EU standards is mandatory [re: Building Regulations Advisory Board information paper, EU Commission].

B. All products & suppliers must demonstrate their understanding and adherence with this mandatory quality system. Prior to the delivery or instillation of any material to site you are required to provide all relevant documentation [Manufacturers Deceleration of Performance etc.] to confirm that these products and materials match or exceed the minimum requirements of this quality control system.

C. These documents must reference the harmonised European Standards [hENs] as they are gradually replacing Irish / British Standards and European Assessment Documents [EADs for construction products not covered].

D. Reference to National additional quality Control in the form of National Annex / NSAI additional Guidance, Standard Recommendations & Minimum Performances if applicable is required.

E. Compliance with Current Building Regulations, relevant Codes, Irish & British Standards, Specifications etc. are still required.

1.9 HVAC Design Parameters

A. All set points must be site adjustable and controllers, detectors, etc. must be selected to operate within the mid-range of the instrument. All controls must be capable of maintaining temperature set-points within the required room accuracy.

1.10 Design Standards

A. The proposed control requirements shall be designed in accordance with:

- BSRIA BG 8-2009 Model Commissioning Plan;
- BSRIA BG 44-2013 Seasonal Commissioning;

- CIBSE Commissioning Code Series C: Automatic Control Systems.

1.11 Open Protocol

A. The BEMS shall consist of microprocessor-based controllers of modular design providing intelligent peer-to-peer processing capability. Equipment provided under this specification shall be fully compliant with ISO 16484-5 / BACnet protocol utilising BACnet/IP and MS-TP communications.

B. Every outstation shall have as minimum the following common open protocols installed including all necessary hardware, software, gateways to achieve them to cater for current and future site integration needs:

a. BACnet/IP;

b. BACnet/MS-TP;

c. BACnet/PTP;

d. BACnet/Ethernet;

e. Mbus incl level converter;

f. Modbus RS485;

g. Modbus RS232;

h. Modbus Master;

i. Modbus Slave;

j. Grundfos & Wilo Protocols;

k. ACSII;

l. KNX.

C. The BEMS system shall be configured in such a manner to limit the number of gateways required.

D. The BEMS Specialist Contractor shall allow for the development and full testing to of drivers to ensure full integration.

1.12 Design Development

A. BEMS Specialist Contractor Project Team for this element of the works shall require a thorough knowledge of the systems incorporated and shall be expected to work closely and co-operatively with the Design Team and client. Full allowance must be made to ensure that this situation occurs. BEMS Specialist Contractor Project Manager shall be fully involved with all stages of the Project commencing with the tendering and design development processes. The design development role of BEMS Specialist Contractor shall include:

a. The generation of technical submission pack and construction information (drawings, schedules, etc.) incorporating the selected components in accordance with the criteria contained in the Specification and Drawings;

b. The provision, where appropriate, of information relating to detailed co-ordination/information aspects (e.g. supports, brackets, builders works, plinths, holes, etc.) to supplement the primary co-ordination already incorporated;

c. The agreement of a manufacturing and installation programme with the client which recognises overall project requirements. Take due account of the phasing of the works and ensure that the system design allows for phased operation of the building where necessary.

B. For each system (i.e. AHU, package plant, switchboard) the BEMS Specialist Contractor shall provide final design proposals for the Design Team to comment before proceeding with manufacture/installation comprising:

   a. BEMS Specialist Contractor shall provide P+I diagrams for approval;

   b. A description of operation from which logic flow diagrams shall be developed to describe the operation of each system to an adequate standard to enable software to be generated direct from these;

   c. A detailed points list (including soft points);

   d. An instrument schedule;

   e. A cable schedule;

   f. An equipment schedule;

   g. A field processor location diagram;

   h. A graphics page agreed with the intended end-user before loading onto the system;

   i. A control valve schedule;

   j. An agreed numbering system, in accordance with that already in existence for the Project;

   k. Equipment labelling to an agreed method.

C. BEMS Specialist Contractor shall demonstrate his installation proposals on drawings for comment by the design team and shall provide installation drawings for any mechanical, electrical and builder's work connected with his works. Installation drawings shall be submitted prior to commencement of manufacture/installation and shall include comprehensive wiring diagrams and detailed drawings of control panels, motor control centres, distributed control panels in addition to layout drawings. BEMS Specialist Contractor shall indicate on the layout and schematic drawings, the precise location of all sensors/controls devices in pipework and ductwork for the proper operation of the installation.

D. The BEMS Specialist Contractor shall demonstrate his interpretation of the control systems in the form of flow diagrams produced in English and not using computer language. Short sections of text may be used to supplement the flow diagrams, but the main "vehicle" shall be the flow diagram. Flow diagrams shall form the basis of the software routines eventually used to control the systems. They shall therefore be submitted prior to commencement of writing the software.

E. A strong emphasis shall be placed on the resilience and reliability of the total system together with the response and command times associated with alarms and starting of plant.

F. Specific care shall be taken to ensure satisfactory response times (with a maximum of 5 seconds for all alarms) of control routines in logical and safe sequential order and the incorporation of safety interlocks and features.

G. It shall be the design intent to have a specific item of plant i.e. Air Handling Units, Boilers, Chillers etc. supported entirely within one BACnet field processor.

H. A multi-level hierarchical architecture shall be employed such that failure of hardware/software functions at any level has minimal effect on the control function. Control conditions and tolerances shall be in accordance with the relevant sections of the specification. BEMS Specialist Contractor shall provide a list of manufacturers for the instrumentation which forms part of their tender submission.

I. Components associated with the BEMS and automatic control system shall be selected to suit the conditions and tolerances specified. Only those manufacturers specified shall be used where detailed in the specification.

J. BEMS Specialist Contractor shall provide a list of manufacturers for the instrumentation which forms part of their tender submission. BEMS Specialist Contractor shall develop a detail design for the BEMS installation based upon the functional descriptions, schematics, I/O schedules and design parameters detailed throughout this specification and the Performance Schedules.

1.13 BEMS Head End and Central Console

A. The BEMS head end and central console location shall be agreed on site. Connectivity shall be cloud based utilising enterprise based software.

B. Human Machine Interface (HMI) shall be via high quality, easy to use graphics based software and graphics user interface (GUI). Central processors, field processors (outstations, data gathering panels etc.) shall be distributed throughout the new building to receive process, distribute and access the information provided by the monitoring points.

C. Field processors and any associated sub system shall be located on dedicated LAN's provided by BEMS Specialist Contractor the topology for which shall be manufacturer specific.

D. An external communication link shall also be provided to connect outstations located in external plant areas such as the generators and air handling plant.

E. The BEMS Specialist Contractor shall be responsible for the manufacture, pre-delivery testing, supply and installation and commissioning of the complete and integrated micro-processor based Building Energy Management System (BEMS) central processor units and all associated hardware and printers.

F. One main server and central workstation computers and peripheral equipment shall be located. Final locations of (BEMS) equipment shall be agreed on site prior to installation.

G. Each (BEMS) central workstation shall comprise of the following hardware components at each of the locations:

    a. The main server including integral 15 minutes uninterruptable battery supply unit (UPS);

H. Both physical and virtual servers shall be supported.

I. A remote access licence/ facility shall be provided by the BEMS Specialist Contractor.

J. Note all licensing costs must be a once off payment included within the contract. There must be no annual licensing costs for the Rotunda Hospital associated with the BEMS system.

K. Each BEMS Console shall include latest Intel® processor which allows high processing speeds for multiple applications.

L. There shall be three workstations setup within the tech services office within Rotunda Dublin.

M. Each BEMS workstation shall include:

    a. 20" colour graphic monitors as standard;

    b. Laser colour printer for graphical and pictorial output (A3 size);

    c. High speed communications link.

N. Power supply unit complete with electrical surge protective devices and all emissions filtering equipment.

O. The server shall be provided at minimum with 25.0 % spare expansion slots, 4 USB Ports, 2 printer ports and 2 serial ports to accommodate future requirements including the loading of emergency light testing, asset management software shall be procured and integrated separately by the Client.

P. The BEMS specialist contractor shall provide with their tender, full details on the proposed server and all hardware components. A dedicated remote dial in facility shall be provided by the BEMS Specialist Contractor to allow the BEMS to be viewed over a secure cloud platform. Information shall be displayed in graphical format and provide access on a selective basis to undertake fundamental operations including alarm acknowledgement, commanding, setting up trend logs and, generating reports. The BEMS Specialist Contractor shall include for pre-delivery testing of all equipment and software proposed, proving software and final operational acceptance test of the complete BEMS.

1.14 Motor Control Centres

A. The BEMS Specialist Contractor shall provide wiring and layout diagrams for all motor control centres indicating all necessary power and control circuitry. All wiring is to be indicated including "internal" wiring and "field" wiring to remote devices.

B. The BEMS Specialist Contractor shall Manufacture, supply and install all Motor Control Centres (MCCs) following approval of manufacturing drawings. Design MCCs to withstand the anticipated fault levels at the point of coupling to the network. Network Characteristics to be advised, however, for tender purposes assume 50 (kA) for 1 second.

C. AHU / equipment panels shall have separate control & power cubicles that shall contain all power wiring & controls associated with the air handling unit. All control panels shall be supplied installed tested & commissioned by the BEMS Specialist Contractor.

D. Any interconnections between panels shall utilise 24V DC interface relays in the control panel (110 V shall only be considered if with the full agreement of the Contractor).

E. All motor control panels shall be supplied, off loaded, lifted into position, assembled, installed, tested and commissioned by the BEMS Specialist Contractor all as detailed within the specification. Where required, purpose built concrete bases and panel support frames shall be provided by the contractor.

F. Each Motor control panel shall contain a door mounted interlocked isolator, main circuit breakers, control circuit transformer motor starters and indicating lamps. The panel shall be prewired to the extent that only external wiring connections to knife type terminal blocks shall be installed. All cables with connections external to the control panel shall pass through knife type terminals.

G. Each control panel shall be equipped with a hardwired shutdown facility (via local interface modules supplied by others) for fire condition via two volt-free contacts. These signals shall be hardwired into each drive stop/start circuit via multiple relays (one contact per drive) and patch panels to permit future configuration of shutdown signals. Certain control panels may require 6 – 8 separate control circuits with individual fire interlocks.

H. BEMS Specialist Contractor shall maintain all necessary segregation of power and controls cabling to ensure the satisfactory operation of the system.

I. Control panel enclosures to be of sheet steel construction with lockable doors by barrel key. The internal layout, equipment installation and wiring to be carried out by the BEMS Specialist Contractor own operatives.

J. Control panel content shall include:

a. Non-interlocked internal lockable isolators for mains supplies.
b. Integral uninterruptable battery supply for the control components (battery to provide 15 minutes minimum) and field instrumentation (BEMS shall monitor Battery fault).
c. Suitably rated 24 V DC and AC control and instrumentation power supplies and distribution.
d. Field processors, system controllers/gateways/interfaces.
e. Interlock and interface relays.
f. Signal conditioning devices and transducers.
g. Electrical terminals for connections to packaged plant (e.g. pressurisation plant, field control devices and interlocks e.g. fire override signals.
h. Door mounted signal and alarm lamps multi-cluster high brightness LEDs, on/off/auto switches and associated reset buttons.
i. Compartmented to segregate power and control sections.

K. The BEMS Specialist Contractor shall provide with their tender data loggers and software to facilitate seasonal commissioning. This information shall be used to assess internal conditions and the performance of systems and the building as a whole.

1.15 Occupant Controls

A. The occupant controls shall be linked to, and communicate over, the IT/BEMS converged communications network.
B. The occupant controls shall control the relevant items of plant (i.e. local fan coil units).
C. The status of each occupant controller shall be viewed and overridden via the front end.
D. The occupant controls shall allow:
   a. Adjustment by the occupants of the set-points;
   b. Definition and adjustment by the BEMS operator, of high and low limits for each set-point.
E. A facility to allow the global alteration of set-point and high/low limits via the operator workstation.
F. An override facility to allow plant operation during out of hour's occupation (for a duration of 1 hour) through a customisable dashboard with the requisite security clearances.
G. The occupant controls are intuitive to use and clearly labelled.
H. For temperature control ensure that hot/cold and/or red/blue indication is used for the occupant interface.
I. For fan speed control ensure that fan fast/slow standard icons/indicators are used.
J. Ensure the +/- or ↑↓ symbols are not used without clarification of the controlled function.
K. Controllers shall be mounted a minimum of 1,200 (mm) above finished floor level.
L. The controllers shall be of brushed stainless steel with bevelled edges with full colour LCD display. The controller IP30 and shall have a de-mountable sensor housing/baseplate arrangement.
M. The cover plate to the controller shall facilitate the swap-out and interchangeability of symbols and control interfaces to suit the area served.

N. The local controller shall also include a RJ45 coms link to facilitate controller interrogation and programming and access to the BEMS network;

O. It is a fundamental requirement that occupant controls are not adversely influenced by localised sources of cold air, draughts, heat convection and or direct sunlight. If it is determined that such influences give rise to operational errors, the contractor shall be responsible for the relocation of the occupant controller.

1.16 Obsolescence

A. The BEMS system hardware and software components shall have a minimum in-service service and support by the parent controls manufacturer of 10 years.

B. Future system upgrades shall be backward compatible to the fullest extent.

1.17 Quality Assurance

A. The BEMS Contractor shall satisfy the following requirements:

a. Provide proof of an established trading record.

b. The BEMS Specialist Contractor must demonstrate previous experience within a critical healthcare environment and working in a live environment. The existing BEMS and M&E systems must be maintained live through the duration of the BEMS upgrade works. Out of hours works are to be included as required to achieve this.

c. Provide a current Quality Assurance Certificate to BS5750/ISO-9000 and have held this for a minimum of 8 years. Provide documentation supporting compliance with ISO-9001 (Model of Quality Assurance in Design/Development, Production, Installation, and Servicing). Ensure that product literature provided by the BEMS manufacturer contains the ISO-9001 Certification Mark from the applicable registrar.

d. Provide before order placement proof of ability to supply, on request, quality long term system maintenance and customer care facilities within the locality of the project. Advise the number of 'call out' engineers that can attend site on short notice.

e. Ensure that they have a dedicated systems service infrastructure capable of providing technical support on and off site at all levels together with a corresponding parts replacement service.

f. Provide a commitment that all products supplied will be supported for a minimum of 10 years following range replacement or obsolescence.

g. Capability of providing an emergency service on a 24-hour, 7-day-a-week basis if required at future date by the Employer / FM.

h. The BEMS architecture shall consist of the products of a manufacturer regularly engaged in the production of Facility Management Systems and shall be the manufacturer's latest standard of design. Controllers and DDC (Direct Digital Control) system components shall be current production products utilising BACnet/IP and MS-TP communications.

i. Each MCC panel must be standalone on a network failure.

1.18 Submittals

A. Description of operation and logic diagrams including:

a. Description of the control systems indicating al set points, alarm conditions, time schedules and the exact method of control for each plant or system

b. BEMS topology showing all DDC controllers, operator workstations, networks repeaters, and network wiring.

c. One-line schematics and system flow diagrams showing the location of all control devices.

d. Points list for each DDC controller, including: Tag, Point Type, System Name, Object Name, Expanded ID, Display Units, Controller Type, Address, Cable Destination, Module Type, Terminal ID, Panel, Slot Number, Reference Drawing, and Cable Number.

e. BEMS Contractor's own narrative for each sequence of operations.

f. Sequences shall reference input/output and software parameters by name and description.

g. The sequences of operations provided in the submittal by the BEMS Contractor shall represent the detailed analysis needed to create actual programming code from the design documents.

h. Points shall be referenced by name, including all software points such as programmable set points, range limits, time delays, and so forth.

i. The sequence of operations shall cover normal operation and operation under the various alarm conditions applicable to that system;

j. Elements to be included within the digital safety file.

B. MCC manufacturing drawings.

C. DPU / DCP manufacturing drawings.

D. Layout drawings of field located devices.

E. Commissioning and testing results

F. Record "As Built" drawings

G. Operation and Maintenance Manuals

H. Programme and outline details for Employer's training.

I. Control Damper Schedules. This spreadsheet type schedule shall include a separate line for each damper and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Blade Type, Bearing Type, Seals, Duct Size, Damper Size, Mounting, and Actuator Type.

J. Control Valve Schedules. This spreadsheet type schedule shall include a separate line for each valve and a column for each of the valve attributes, including: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close-off Pressure, Capacity, Valve CV, Calc CV, Design Pressure, Actual Pressure, and Actuator Type.

K. Data sheets of all equipment used. This includes, but is not limited to, the following:

a. DDC panels, peripherals, sensors, actuators, dampers, control air system components, and so forth.

b. Range and scale information for all transmitters and sensors. This sheet shall clearly indicate one device and any applicable options. Where more than one device to be used is on a single sheet, submit two sheets, individually marked.

c. Training course outlines for each four-hour session.

d. Data sheets for all operator workstations, local access panels, and portable operator terminals.

L. Software manuals for all applications programs to be provided as a part of the operator workstations, portable operator terminals, programming devices, and so forth for evaluation for compliance with the performance requirements of this Specification.

1.19 Building Energy Management System

A. The Building Energy Management System shall provide total control of all the HVAC systems. Provide MCC's with standalone outstations such that plant will continue to operate in the event of the central station failing.

B. Provide the following facilities:

1. Time schedule operation for each item of plant or system to suit the operational needs of the building owner and the usage patterns for the various types of building.
2. Equal running. Change of lead machine on a time programmed basis to ensure equal running. This applies to the following plant:
    - Chillers;
    - Boilers;
    - Pumps;
    - Fans (where run & standby provisions are made);
    - HWS water heaters;
    - Boosters.
3. Provide automatic changeover on failure for all pumped systems where duplicate pumps are provided.
4. Provide status (on/off) and trip indication for all items of plant.
5. Provide ability to have auto-rest to network defined base point of user adjustment. Adjustment to affect all local plant.
6. Provide hours run for the following plant which is to be used for a future planned maintenance programme, provided by the BEMS Contractor:
    - Chillers;
    - Boilers;
    - CHP;
    - Air Handling Units;
    - Extract Fans;
    - Kitchen Extract Fans;
    - Toilet Extract Fans;
    - Pumps;
    - Generators.
7. Provide a record all alarms and changes to set points etc.
8. Provide a colour VDU terminal to display all HVAC schematics and operator graphics user interface with the BEMS system.
9. BEMS Contractor to provide for alarm priorities and actions required in discussion with building user.

10. BEMS Contractor to allow for integrated commissioning and attendance on the commissioning contractor.

C. BEMS Monitoring/Control Functions. BEMS System to monitor the following conditions for all plant as a minimum:

1. All Air Handling Plant
    i. Damper position open/closed
    ii. Frost coil off temperature & alarm
    iii. Filter blocked alarm
    iv. VSD frequency setting
    v. Cooling Coil off temperature
    i. Reheat Coil off temperature
    ii. Thermal wheel off temperature
    iii. Run-around coil on temperature
    iv. Run-around coil pump failure
    v. Run-around coil off temperature
    vi. Supply air temperature
    vii. Air flow failure alarm supply
    viii. Duct humidity & alarm
    ix. Extract fan air flow failure alarm
    x. Heating & cooling coil valve positions
    xi. Atmospheric CO_2 concentration
    xii. Supply and return air in-duct pressure
    xiii. Supply air flow rate
2. Boiler Plant
    i. Ambient temperature
    ii. Internal temperature(for each zone)
    iii. Zone flow temperature (for each zone)
    iv. Common boiler return temperature
    v. Common boiler flow temperature
    vi. Individual boiler flow temperature
    vii. Heating pump failure
    viii. Pressurisation unit high/low limit alarm
3. For each Chiller
    i. No flow alarm
    ii. Chilled water primary pump failure alarm
    iii. Chilled water secondary pump failure alarm
    iv. Chilled water high temp alarm

v. Chilled water low temp alarm
vi. Press unit high/low limit alarm
vii. Hours run for each chiller
viii. High oil pressure
ix. Low oil pressure
x. Compressor 1 Fault
xi. Compressor 2 Fault
xii. Low temperature alarm
xiii. Head pressure fault

4. For VRF
   i. Common Alarm from central plant
   ii. Running Status of each fan coil unit
   iii. Room Air Temperature for each fan coil unit
5. Water Controls
   i. Mains water pressure
   ii. Water level
   iii. High level alarm
   iv. Low level alarm
   v. Leak detector operated alarm
   vi. Water booster set common alarm
6. Domestic Hot Water System
   i. High temperature alarm
   ii. Low temperature alarm (return)
   iii. Low temperature alarm (flow)
   iv. Pump failed

1.20 BEMS System Architecture

A. The Building Energy Management System provided shall include the capability for unlimited users to access the BEMS concurrently from remote locations via the internet/cloud. Internet access shall be accomplished by use of standard internet browser software applications such as Google Chrome or Microsoft Internet Explorer and shall not require the use of proprietary access software. Interface shall be to the entire BEMS and shall provide the capability to monitor all I/O and adjust parameters.

B. The supplied BEMS system shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BEMS shall not be limited to use only open communication protocol standards but be able to also integrate a wide variety of third-party devices and applications via existing vendor protocols and through the latest software standards.

C. The user interface shall be in the form of dashboards and shall be fully customisable to suite end-user needs.

D. Specifically, the BEMS shall be able to demonstrate:

a. An open and published protocol fully compliant with ISO 16484-5 / BACnet protocol utilising BACnet/IP and MS-TP communications.

b. Ability to connect with BACnet certified open protocol devices;

c. Must be able to use TCP/IP networking protocol and access all data using a standard WEB browser such as Google Chrome and Internet Explorer;

d. Workstation applications must be able to use data supplied through third party OPC (OLE for Process Control) Servers;

e. The operator workstation must have the ability to support third party ActiveX controls in an integrated environment;

1.21 BEMS Alarm Priorities

A. The following schedule indicates the minimum requirements for alarms and identifies alarm priorities as explained elsewhere:

- Level 1 (high priority),
- Level 2 (medium priority)
- Level 3 (low priority or maintenance flag).

1.22 Time Synchronisation

A. All time-dependant BEMS components to be synchronised via the front end.

1.23 System Security

A. Operator access shall be restricted to the following levels:

Security Level	Access
1	Ability to display all data points.
2	As Level 1 with ability to initiate data logging functions.
3	As Level 2 with the ability to change user-adjustable set-points and time
4	As Level 3 with the ability to change control strategies, schematic/graphics functions and password assignment.

Table 1.1 BEMS front end access levels.

2 Description of Control Systems

2.1 General Interfaces

A. Pick up common alarms from the following plant control panels supplied by other subcontractors.

a. CCTV;
b. Security and access control system;
c. Sewage pump panels;
d. Sump pump panels;
e. Firefighting lift sump pumps panels;
f. Rainwater harvesting pump panels;
g. Smoke evacuation system panel;
h. UPS control panel;
i. Emergency lighting control panel;
j. Stand-by generator control panel;
k. Bulk fuel oil store control panel;
l. Motorised fire/smoke damper control system;
m. Smoke shaft damper control system;
n. Building maintenance unit control panel;
o. Variable speed drives (BACnet and hardwired).

2.2 Control in a Fire Condition

A. The BEMS is to interface with the fire alarm systems and the following alarms shall be picked up from the fire automatic detection and alarm system main control panels.

a. Common panel fault;
b. Fire condition;
c. Fault condition.

B. On fire alarm initiation a signal shall be relayed to each of the MCCs. The interaction with the fire alarm system is to be compliant with HTM guidance specifically in relation to operation theatres.

C. When the fire alarm panel is reset the plant shall automatically come in to operation in an orderly manner which minimises the load upon the panels.

3 Controls Narrative

3.1 General

A. Plant control strategies shall be applicable and appropriate for the mechanical plant and equipment installed as part of the project.

B. The control strategies for individual plant and equipment are those provided in the BSRIA Library of Control Strategies: AG 7/98.

C. Detailed control strategies shall be issued prior to commissioning of the BEMS installation.

D. Night set back strategies are to be implemented for HVAC systems to reduce energy consumption on the campus. These are to be complete with manual over-rides for staff to operate in the event HVAC systems are required for emergency situations.

3.1.1 Frost protection

A. Provide frost protection routines to operate plant and pumps in order to protect building services systems and their components from frost damage.

B. Provide the following two stages of protection:

a. Ensure that when the outside temperature falls to the operator set minimum frost-protection temperature, the selected pumps start and circulation is established through pipework systems and their components. Allow the operator to pre-select which plant is to be started. The automatic standby plant is to operate on failure of the duty plant.

b. Ensure that when the return temperature falls below the operator pre-set minimum, the full frost-protection facility is initiated.

c. Ensure that for heating systems, the heat source is turned on and operated to maintain the return flow temperature above the pre-set minimum. Ensure that specified protective devices activate for other liquid systems.

C. Provide a facility to allow frost protection to be logged together with data and time.

3.1.2 Building/Plant Protection

A. Provide protection routines to operate the plant in order to protect the building fabric and its contents against the effects of low internal temperatures and of condensation.

B. Ensure that if the internal air temperature falls below the pre-set protection temperature, the heating system and related plant is turned on and heat supplied to maintain the air temperature at or above the protection set-point temperature.

C. Ensure that the building/plant protection routine overrides other control functions unless otherwise specified.

D. Ensure that protection operates whenever the normal heating is switched off.

3.1.3 Safety Interlocks

A. Ensure that all safety interlocks are hardwired and have precedence over all other control functions.

B. Ensure that safety interlocks can only be reset manually and locally (not from the operator workstation).

C. Ensure that all hardwired safety interlocks have corresponding software interlocks to prevent cascading nuisance alarms.

3.1.4 Fire Alarm System Interlock

A. The Fire Alarm System will provide a “Fire Alarm” output to the BEMS, via a volt free contact.

B. In the event of a “Fire Alarm”, non-essential HVAC plant shall be shutdown via hardwired interlock.

C. A “Fire Alarm” indicator lamp on the door of the MCC will illuminate and an alarm is sent to the BEMS Supervisor.

D. When the “Fire Alarm” condition resets, the BEMS will return the HVAC plant to normal operation, using the “Power Fail Restart” routine.

3.1.5 Power Fail Restart

A. If mains power fails, the HVAC plant powered from an MCC will be subject to an uncontrolled shutdown. When mains power supply is restored, a controlled Start-up sequence will take place.

B. The BEMS will hold off the HVAC Plant for a period of 60 seconds (adjustable ± 30 seconds) and will then start the HVAC Plant on a phased basis at intervals of 10 seconds.

3.2 Natural Gas System

3.2.1 Natural Gas Detection System Interlock

A. The LPHW boilers and domestic hot water heaters are gas-fired, running on natural gas.

B. In the event of a gas leak being detected by the natural gas detection system, the LPHW boilers/gas fired water heaters will be disabled by hardwired interlock.

C. A gas detected alarm indicator lamp will be illuminated at the local MCC on this condition.

D. This gas detected alarm status is also monitored by the BEMS and an alarm will be raised to the BEMS Supervisor on a gas detected condition.

E. The fire alarm and the gas detection systems operate the gas slam shut valve independently of the BEMS. If a fire alarm occurs, or gas is detected, the gas slam shut valves will be closed via hardwired interlock with the fire alarm and the gas detection systems.

F. When the fire alarm or gas detected conditions reset, the LPHW and DHWS system controls will resume normal operation.

3.2.2 Natural Gas Detection System Common Alarm

A. The BEMS monitors the Natural Gas Detection System Common Alarm status via a volt free contact, at the unit’s control panel.

B. If the unit reports a Common Alarm, an alarm will be raised to the BEMS Supervisor.

3.3 Time Schedules

A. Ensure that each field controller is capable of enabling plant according to multiple pre-set time programmes. Ensure that it is possible to schedule each item of plant for a minimum of three separate switching periods per 24 hours. Ensure that separate schedules can be defined for each day of the week.

B. Ensure that individual time schedules can be grouped to form global time schedules.

C. Ensure that time schedules can be defined on a weekly basis on a single ‘page/screen’.

D. Ensure that time schedules can be defined 12 months in advance.

E. Allow fixed extensions and contractions to time schedules. Ensure that the time schedule reverts to the ‘normal’ switching periods following the extension/contraction period.

F. Allow time schedules to be copied from existing schedules.

G. Ensure that time schedules can be linked to optimum start/stop control facilities.

H. Provide an optimum start/stop override facility for user-defined override days. Ensure that optimum start/stop control is enabled following the override period.

I. Provide automatic switching between BST and GMT and back.

J. Provide an operator override facility.

K. Ensure that time schedules can accommodate leap years.

3.4 Plant Start/Stop Control

A. Ensure that field controllers are capable of starting and stopping plant including any specific requirements for 'off' position or status of plant items, valves and dampers, etc.

B. Field controllers shall be capable of automatically enabling standby plant on failure of duty plant. Ensure that the field controllers can automatically report plant failure alarms at the front end. Ensure that the failure of a flow switch or other device does not continuously cycle plant.

C. Ensure that if a flow switch fails the operator has the option to force either the duty or standby plant to come on.

D. Provide the graphic user interface the option to override any start/stop action configured within the field controllers. When reverting to normal automatic control, ensure that the original program is automatically reinstated and updated to the correct time.

E. Provide delayed plant-starting facilities in order to reduce power surges. Ensure that it is possible to start plant sequentially by adjusting the delay period for each item of plant.

F. Ensure that delayed plant-starting occurs following power failure/re-instatement and plant shut down/restart on fire/fireman override.

G. Provide the operator with a facility to specify minimum on/off cycle times and/or the maximum number of starts per hour for specified items of plant.

H. Provide a plant protection routine that enables the operator to select and automatically run items of plant for short periods during out of season shut-down. Run periods shall be operator adjustable.

3.5 Plant Sequence Control

A. Provide sequence control routines to automatically sequence the operation of multiple items of plant by monitoring load parameters and efficiently matching the plant to the load.

B. Ensure that it is possible to define different automatic sequences of control.

C. Provide the operator with a facility to override the automatic sequence and define an alternative sequence.

D. Ensure that the set-point values for each control action are variable and adjustable by the operator. Ensure that associated alarm limits are modified automatically.

E. Allow the operator to adjust switching control differentials to prevent short cycling.

F. Ensure that the routines also include a facility to operate all plant ancillaries associated with sequence control, unless these have been specifically excluded.

G. Ensure that the routines include the facility to proceed with the defined sequence when one of the items of plant in the sequence is isolated or fails to operate (unless the safety requirements dictate otherwise). Ensure that failed items of plant are removed from the sequence.

3.6 Plant Rotation Control

A. All field controllers shall be capable of alternating the lead plant items where duty and standby equipment is installed. Ensure that this is achieved both by an operator command and on a time-scheduled basis.

B. Rotation control shall be provided on the basis of run hours, elapsed time and calendar basis.

C. Provide routines to ensure that when the maximum number of start/stop cycles for a particular plant is reached, its schedule is automatically modified, e.g. by rotating the standby equipment or changing the lead machine.

D. Ensure that each item of plant operated under rotation control can operate at any stage of the rotation sequence (e.g. 1-2-3, 2-1-3, 3-2-1).

E. Ensure that the plant rotation control can accommodate a plant failure condition, in such a way that a failed item of plant is 'replaced' by the next in the rotation cycle. Ensure that an alarm condition is raised in response to plant failure.

F. Rotation control can be initiated outside normal operating periods if required.

3.7 Weather Compensation

A. Provide weather compensation routines to control the heating system in relation to external weather conditions. Provide facility to adjust temperature and flow-rate settings for the heating system to re-define the weather compensation.

B. Provide automatic adjustment to the weather compensation by comparing measured and required space temperatures with the outside conditions and provide the facility to correct the compensation where a significant difference between the two space temperatures occurs.

C. Ensure that abrupt changes in the heating system performance or space temperature shall not adversely affect the automatic adaptive compensation process.

D. Provide a single weather compensation curve for each zone irrespective of the number of temperature sensors provided in the zone.

E. Ensure that the routines respond to the reset signals arranged to achieve boost, night set-back and boiler safety.

F. Ensure that air temperature sensors associated with the compensator are positioned correctly in order to provide representative readings.

3.8 LPHW System

3.8.1 LPHW Pressurisation Unit

A. The LPHW Pressurisation Unit fills the LPHW heating system from the mains water supply. It automatically tops up the system as required.

3.8.2 LPHW Low Pressure Interlock

A. The LPHW Pressurisation Unit will provide a "Low Pressure Cut-out" output to the BEMS, via a Volt free contact at the Unit's Control Panel.

B. If the unit reports a Low-Pressure Cut-out, e.g. because of a leak, the LPHW Boilers and all LPHW Circulation pumps will be shutdown via hardwired interlock

C. A "Low Pressure" indicator lamp on the door of the MCC will illuminate and an alarm is sent to the BEMS Supervisor.

D. When the low-pressure alarm condition resets, the LPHW system controls will resume normal operation.

3.8.3 LPHW High Pressure Interlock

A. The LPHW Pressurisation Unit will provide a “High Pressure Cut-out” output to the BEMS, via a Volt free contact at the unit’s control panel.

B. If the unit reports a High-Pressure cut-out, e.g. because of a blockage, the LPHW Boilers and all LPHW circulation pumps will be shutdown via hardwired interlock

C. A “High Pressure” indicator lamp on the door of the MCC will illuminate and an alarm is sent to the BEMS Supervisor.

D. When the High-Pressure alarm condition resets, the LPHW System controls will resume normal operation.

3.8.4 LPHW Pressurisation Unit Common Alarm

A. The BEMS monitors the LPHW Pressurisation Unit Common Alarm status via Volt free contacts, which are connected in parallel, at the unit’s control panel.

B. The unit will report a Common Alarm if: Pump #1 trips, or Pump #2 trips, or a Low Water Level fault occurs.

C. If the unit reports a Common Alarm, an alarm will be raised to the BEMS Supervisor.

4 Products and Materials

A. The BEMS Control specialist contractor shall take into account all requirements BSRIA AG 9/2001.

4.1 Motor Control Centres

A. The BEMS Specialist Contractor shall provide composite Motor Control Centres (MCCs) for the entire project as described herein and also as detailed on the drawings.

B. Motor Control Centres to be manufactured in accordance with BS EN 60439. Provide the Motor Control Centre Panels suitable for internal or external locations with the required degree of protection and form of internal separation indicated. Protection to be as BS EN 60529.

C. Internally located panels and inverters to be fully enclosed cubicle type assemblies, fully compartmented type Form 2B/IP54. In all instances the controls must be housed with dedicated and completely separate section.

D. Externally located panels and variable speed drives/inverters to be fully enclosed cubicle type assemblies, fully compartmented type Form 2B/IP65. In all instances the controls must be housed within a dedicated and completely separate section.

E. Externally located inverters are to be suitable for the environment and fully enclosed and weather proofed. The inverters shall be provided with ventilation and heating and shall be capable of operating between -10.0 (°C) to 50.0 (°C).

F. Internal control panels shall be Form 1 or as otherwise scheduled.

G. During a loss of normal power an internal UPS system shall be provided to support each MCC and control panel. The run-up time of the stand-by generators is 30 (s) however the UPS system shall be designed to allow the normal operating functions to be maintained for a period of 1 hour. After this time the control sequences shall go to the normal system shutdown conditions.

H. In addition to the building controllers, the UPS shall be sized to cater for the atrium ventilator actuators.

4.2 Control Panel Construction

A. Panels to be modular form with modules not exceeding 1,200 mm wide, 2,700 mm high or a weight of 0.5 tonnes. Provide removable lifting eyes at suitable locations for modules over 50kg.

B. Lifting eyes shall be provided at reinforced points on the top of all panels. Suitable plugs (steel or PVC) shall be provided to cover the holes after the eyes have been removed to prevent the ingress of dust and water to the specified IP rating.

C. Provide sufficient but at least two gland plates for cables to enter and leave the panel. Gland plates to be suitable for the imposed loads of trunking, conduit and cables. Trunking and conduit to be made off onto the gland plates.

D. Cable or trunking access shall be required for suitable entry on top or bottom of the panel as dictated by the panel location. Removable bolt–on gland plates shall be provided at these entries and the plate shall be adjacent to the appropriate terminal (Bar).

E. All accessories mounted through the panel skin shall be suitably rated and fully compliant with the specified IP rating.

F. Provide panels of best quality folded zinc coated mild steel sheet minimum thickness 1.6mm, braced and stiffened where necessary. Panels to be degreased and chromate etched, followed by two coats of primer and stove enamelling. Internal surfaces and component mounting plates shall have a matt white finish.

G. Panels shall be of welded construction using zinc coated mild sheet steel, braced and stiffened where necessary.

H. All external edges and corners shall be rounded (i.e. either formed or suitably dressed to prevent sharp edges and corners). Any cutting of manufactured finished surfaces shall be de–burred and left without sharp edges or protrusions.

I. Internal partitioning plates separating compartments shall be sheet steel.

J. Panels up to 1200 mm x 1200 mm may be wall mounted. Larger panels to be floor mounted on purpose made integral plinths. Rodent screens to be provided to prevent rodent entry into panels.

K. All equipment shall be protected by a dedicated fuse or circuit breaker.

L. All panels to incorporate the following:

   a. 1 No. Main Incoming Lockable Isolator
   b. Fuses/fused switches or circuit breakers for each item of plant
   c. Starters for each motor of 0.37kW or over:-
   d. Motors up to 0.75kW, 240V, D.O.L.
   e. Motors 0.75kW – 3.5kW, 415V, D.O.L.
   f. Motors 3.5 kW to 20 kW, 415V, Star Delta
   g. Motors > 20kW Soft Start
   h. 1 Ammeter
   i. 1 Voltmeter
   j. Door interlocked isolator for each door/compartment
   k. Separate controls section (no door interlock required)
   l. Hinged and lockable flush mounting access doors
   m. 2 Identical keys for every lock and panel
   n. 1 Mains incoming neutral link
   o. 1 Set Control of circuit fuses for low voltage transformer
   p. 1 Test switch for operating control voltages only with all power circuits de-energised
   q. 1 Set numbered terminals
   r. 1 Set engraved labels to BS5378 Part 1
   s. BEMS control outstation
   t. 1 set indicating lamps (Run, trip and alarm)
   u. 1 lamp test facility (common)
   v. 1 Power ON lamp
   w. Space for future expansion (20%)
   x. Common and remote alarm terminals

y. Audible alarm and mute/test facility

z. Earth (Bar) with test link

M. All motors to have three position Hand/Off/Auto switches with run and trip lights. In the hand position no safety features or interlocks are to be overridden.

N. Where duty and standby equipment is provided arrange for auto-changeover and prevent simultaneous operation via hard wired links, between panels if required.

O. All plant shall be controlled such that on initiation the plant starts up in a safe, logical way and in a sequence that minimises disturbances on supply network whilst starting drives.

P. Within the controls section a surface mounted single switched metal clad socket to BS 1362 shall be fixed supplied from a 5A fused source. This is for use by the controls specialist, for lap top computers, data logging equipment or test sets, etc. This socket and associated 240-volt supply cabling shall be suitably segregated for from the control wiring and devices.

Q. Ventilation fans shall be incorporated as required to maintain the internal temperature below the working temperature of the internal components.

4.3 Control Panel Wiring

A. Control Wiring

a. Provide control circuit transformer and use ***24 Volt AC*** operating supply to suit control components. Segregate control wiring from power wiring. Provide ventilated plastic trunking for control wiring. Identify each end of the wire with a unique number using colour coded 'O' ring markers. Fit lugs at termination points. Use cabling of 1.5mm² minimum and of the LSF high temperature rating (Tri-rated). Life safety control wiring and interfaces with fire alarm and fireman's override shall be in fire resistant cable e.g. Pirelli FP400 to BS 6387. See fire alarm and electrical specification for fuller details.

B. Power Wiring

a. Route power cabling and take account of thermal effects when grouping cabling. Identify each end of the wire with a unique number using colour coded 'O' ring markers. Fit lugs at termination points. Supplies to fire and smoke dampers shall be in fire resistant cable to BS 6387. See fire alarm and electrical specification for fuller details.

C. Terminals

a. Numbered identification (using a proprietary system specially designed for this purpose) to be provided on all terminals corresponding with wire numbering. Terminals to be compatible with the incoming or outgoing cabling located for ease of access and maintenance. Provide clamp type terminals for control wiring and stud type terminals for heavy duty power wiring. For screened cables termination shall not compromise the screening.

b. Shroud all terminals of voltages in excess of 24 Volt AC.

4.4 Control Panel Accessories

A. Lamps

a. Use 12-volt low wattage LED indicator lamps colour coded as follows:

Lamp Colour	Indicator
Red	Trip/Alarms
Yellow	Duty
Green	Run
White	Supply Healthy

Table 4.1 Control panel lamp colour code.

b. Lamps to be flush mounted with lamp changing from the front. Lamps to be mounted on access doors.

B. Starters

a. Comply with BS EN 60947 Part 4. Ensure all contacts and coils are replaceable. Provide indicator lamps as specified. Starters to be of block construction with in line terminals and contacts. Overloads to be of the same manufacture as the starters, thermal type with direct connected heaters and ambient temperature compensated. Selection of overloads to be 0.6 - 1 times overload rated current. Provide changeover contacts for tripped condition. Ensure that the contactor has the ability to fit auxiliary contact blocks.

C. Protection

a. Provide short circuit protective devices to each outgoing circuit. Protection to be fused switch, or circuit breaker sized to suit the full load and starting effects of the connected device. Ensure type 2 co-ordination to IEC 947.

b. Fuses to be manufactured to BS EN 60269 Class Q1 motor rated and circuit breakers to BS EN 60947.

D. Fuse Switches/Switch Fuse and Isolators

a. Provide units in accordance with BS EN 60947. Provide mechanical interlock so compartment door cannot be opened unless isolator is in the OFF position. The switching action shall be quick make, quick break type. Shroud all terminals which remain live when the unit is in the OFF position. The switches shall be ASTA certified for minimum making and breaking capacity of 50 (kA). Provide clear indication of ON and OFF positions.

E. Component Mounting

a. Components shall be mounted on a DIN rail fixed to the backplate for internal components or on the door. All components shall be mounted on removable backplates.

F. Busbars

a. Provide suitably sized phase bars with full neutral and full earth, fully insulated, fully compartmentalised primary and secondary busbars. All joints and interconnections to be accessible for inspection and tightening.

b. Busbars shall be rated and constructed in accordance with BS 159. Neutral bars shall be the same size as the phase conductor bars.

c. The busbar system shall be housed separately from the panel control sections.

d. The busbar system shall be clearly marked in red capital letters on a white background:

"WARNING – LIVE BUSBARS. SWITCH MAIN ISOLATOR OFF BEFORE REMOVING THIS PANEL"

or a similar wording approved by the ER.

e. Copper busbars shall be air insulated and the phases and neutral bars shall be colour identified. The minimum size of the bars shall be 25mm x 4mm.

f. Busbar chambers shall be arranged for ease of future extension to accommodate further sections.

g. All holes or apertures into the busbar chamber must be sealed to prevent access to live busbars by operatives when working in the main panel or any panel compartment.

G. Voltmeter/Ammeter

a. Provide voltmeter with line voltage and phase voltage selector switch.

b. Provide ammeter with line current and phase amperage selector switch.

c. Indication range should be 90° action from 0 to 125% of full load ratings. Current transformers to be used for ammeters greater than 30 A.

H. Safety Interlocks and Padlocking

a. Where applicable provide padlocking facilities to each outgoing circuit to enable safe working procedures (LOTO).

b. Provide hard wired and mechanical interlocks for all safety devices or procedures (i.e. not software generated).

I. Contactors

a. Contactors shall be of the phase(s) and neutral double break, fully shrouded, module block pattern in accordance with BS 60947 suitable for inductive circuit rating with replaceable main and auxiliary contacts.

b. All contactor control wiring which passes through any adjacent switchgear shall be contained within an internally mounted metal duct/conduit.

J. Remote Local Isolation

a. Local Isolation shall be provided to each piece of equipment, suitably rated, fitted with auxiliary contacts to allow operational status to be determined by control system. Star Delta starting isolators to have auxiliary contact hardwired into control circuit to prevent inadvertent starting. Provide an emergency stop button, push to break type, adjacent to each local isolator. For run and standby plant one dual purpose emergency stop only is required.

K. Electrical Continuity

a. Provision shall be made for the earthing of all non-current carrying panel and equipment metalwork including panel doors to prevent any potential developing across the panel or between any adjoining components.

L. Earthing

a. Provide an earth busbar system across each compartment for ultimate connection to the building earthing system.

b. The unit earthing system shall be capable of carrying the full rated fault current for 1 second. Comply with BS 7430.

M. Audible Alarms

a. Provide each panel with a common audible alarm system which is initiated by any trip or alarm lamp. Provide test facilities and terminals for remote alarm signal. Provide mute facilities with alarm accepted lamp. Ensure subsequent alarms are not muted until accepted.

N. Discrimination

a. Provide verification that final selection of protective devices and fuses ensure correct electrical discrimination.

4.5 BEMS System Structure

A. The Building Energy Management System shall have a PC based supervisor/front end and have a networked distributed intelligent controller/outstation structure. The integration with other intelligent systems in the building as shown on the BEMS network schematic shall take place at management architecture level, PC to PC. While some of the following features may not be required as functions within this current application, they shall be inherent in the design and may be required for future system expansion:

a. Autonomous Local and Wide Area Networks, electrically and operationally independent of each other. Capable of connecting up to 12,000 networked devices such as sensors and actuators, and greater than 250,000 points. Able to support any number of user terminals, either LAN, WAN or locally connected. The interchange of data between network devices shall be without recourse to any central or host computer. The backbone network shall be based on a building controls industry standard of Ethernet, TCP/IP, BACnet (ISO 16484-5 / BACnet protocol utilising BACnet/IP and MS-TP) or equal and approved. The network shall operate at a minimum communication speed of 19.8 (kbit/s) baud rate with full peer-to-peer network communication.

b. Standard RS232c interfaces with the ability to communicate with other PC based systems. The BEMS shall network multiple operator workstations, network controllers, system controllers, and application-specific controllers. The first-tier network shall provide communications between operator workstations and first tier DDC (Direct Digital Control) controllers.

c. Have in-built protection against site local lightning strikes, mains surges and external EM radiation causing the total malfunction of the system. All components shall comply with EU EMC emission standards.

d. Have monitoring facilities to detect failed outstations and other network communications devices.

e. Methods of integration include industry standard protocols such as BACnet, LonMark / LonTalk / Mbus or Modbus or integrator interfaces between co-operating manufacturer's systems.

f. Communicate to user terminals and other sites by web-based applications.

g. Connect remote printers to the network for the relay/direct reporting of alarm messages from network devices.

h. System devices shall communicate via the network to send alarms and monitoring or control data on a request or send basis. A message shall be acknowledged by the receiving device. If not acknowledged, the message shall be repeated by the sending device.

i. Battery back-up of network devices should be available for the full operation of the item for the times indicated in the particular specification.

j. The system shall allow full access via portable terminals at each outstation, for both commissioning and fault Diagnostic Procedures.

B. The programmable levels of access assigned to individual system operators and engineers. The password structure shall ensure protection to change any set point, sequence selection, control and monitoring parameter or any equipment configuration. A common overall system password set and procedure shall be provided whether access is gained from operators' terminals, portable terminals or keypads on single or multi-site schemes. Manual overrides and set point adjustments shall have individual programmable levels to control access according to responsibility and competence of the individual to the priority of the adjustment. The highest level of password shall access the Engineers' utility for both outstations and user terminal configuration. At operator terminals a user logging-on shall be recorded with time/date. Logging off shall be by command or time-out from non-use of the keyboard or mouse with the event again recorded.

C. The system engineer shall be able to add/delete operators and change levels of their access. Users shall be able to change their password/pin numbers at will.

D. The BEMS shall be integrated with the other intelligent systems in line with the specifications and schematics. Industry standard open protocols will be adopted to enable full transfer of data and interoperability subject to user password authorisation. All gateways, devices and routers required shall be provided. High level integration shall be via open protocol BACnet and where appropriate lower level hard wired connections shall be used.

E. The final system design and network detailing, systems integration of the common front end information and generation of common format graphics, trend logs, alarms and management information to provide a full working integrated BEMS installation shall be performed by a specialist BEMS contractor.

4.6 System Addressing

A. System point addressing shall be by English language text identifiers and operating selectors via menus and programmable cross references. Forms of numeric and mnemonic addressing are not acceptable. Multiple point addressing by plant, location or other set attribute shall be possible both as methods of interrogation and control.

B. It shall be possible to easily establish the highest/lowest temperature in a group of similarly labelled sensors, or the widest position of a group of valves. Attributes shall be assigned, amended either locally or via the network from a user terminal. Typical applications for these forms of multiple monitoring/control are chiller/boiler demand control, VAV terminals/AHU inter-control, lighting and energy monitoring.

4.7 Original Equipment Manufacturer (OEM) Supplied Components

A. Where outstations are supplied as dedicated controllers and mounted within OEM supplied packaged plant (A/C Units, AHUs, Fan Coils etc.), the BEMS Specialist Contractor shall complete all the necessary work to connect into the networks, commission the communications and provide the necessary displays. OEM suppliers shall supply the colour graphical displays compatible with their equipment and all supporting documentation for inclusion in the O&M manuals and digital safety file.

4.8 Operator Interfaces

A. Operator stations shall comprise a desktop PC complete with printers and peripherals as below. Other interfaces at motor control panels shall be provided by local keypads with colour touchscreen LCD displays. Operator interfaces shall be available in the following formats:

a. Main Operator Stations, main user facilities, PC complete with LCD colour screen, CD storage, printers, generally giving access to whole system.

b. The operator workstation software shall provide context-sensitive help menus and instructions for each operation and/or application currently being performed.

c. All controller software operating parameters shall be displayed on graphics or user pages for the operator to view/modify from the operator workstation. These include: set points, alarm limits, time delays, PID tuning constants, run-times, point statistics, schedules, etc.

d. Portable versions of above for both desk-top and outstation local interrogation.

B. A web server interface shall be provided that allows building users to access their BEMS data via the internet or intranet using standard browser software. This interface shall use HTML-based pages to send and receive data from a BEMS system server to a web browser. 5 portable tablet style internet browser terminals shall be provided and commissioned for facilities management staff to use for offsite relay of alarms and simple diagnostic information.

C. The software shall run on the Microsoft Internet Explorer (11.0 or higher) and Google Chrome (for Windows 7/8) browsers.

D. The interface shall provide four levels of user access. Users will range from read-only access to BEMS data (level 1) to having complete access to view and modify BEMS data and user accounts (level 4).

E. The interface shall provide a user account utility, complete with a user profile database that includes user ID, encrypted password, access level, and language preference. Operators with the appropriate access level shall be able to add, modify, and delete users within the user profile database, as well as change users' access levels.

F. The interface shall provide a means by which the user can collect items (BEMS data points) into "summary" groups. This functionality shall allow authorized users to perform actions ranging from viewing summary groups, to adding items to or deleting items from groups, to creating new summary groups.

G. The web-based interface shall provide full functionality for user friendly monitoring and remote fault diagnosis.

H. The interface shall provide navigation tools for easy and intuitive moving between systems views. In addition, it shall provide tools for gaining access to help and for logging out of the system.

4.9 Operator Interface Facilities

A. Each workstation shall receive and process alarms sent to it by the control system. The alarm management portion of the operator workstation software shall, at the minimum, provide the following functions:

a. Log date and time of alarm occurrence.

b. Generate a "Pop-Up" window informing an operator that an alarm has been received.

c. Allow an operator, with the appropriate security level, to acknowledge, delete, or disable an alarm.

d. Provide an audit trail for alarms by recording operator acknowledgement, deletion, or disabling of an alarm. The audit trail shall include the name of the operator, the alarm, the action taken on the alarm, and a time/date stamp.

e. Record all alarms received at an operator's workstation to that workstation's hard drive.

f. Allow the operators to view/manage the alarm data archived to hard disk. Selection of a single menu item or tool (Bar) button shall allow the user to acknowledge, disable, delete, or print the selected alarm.

g. Alarms shall be generated by the operator workstation for any controller that is "off-line" and is not communicating, or that does not have an active control program loaded.

h. Changes made to alarm set points from the Operator Workstation shall directly download to modify the controller alarm management database.

i. Selection of a single menu item or tool (Bar) button shall print any displayed alarm report on the system printer for use as a building management and diagnostics tool.

B. Reports shall be generated and directed to one of the following: workstation displays, printers, or disk. As a minimum, the system shall provide the following reports:

a. All points in the network.

b. All points in a specific controller.

c. A listing of a user-defined group of points in the network. There shall be no limit to the number of user-defined group.

d. All points currently in alarm.

e. All points in hardware override.

f. All disabled points.

g. All weekly schedules.

h. All or selected point attributes, including, but not limited to:

i. Measurement Values

j. Set points

k. Alarm Limits

l. Statistics

m. Run Times

n. All programmed holidays and associated schedules.

o. All disabled alarms.

p. All active, unacknowledged alarms.

q. All active, acknowledged alarms.

r. Any and all other controller operating parameters.

C. Reports shall be provided for specific point types, for each logical point group, for user-defined groups, or for the entire facility.

D. The system shall allow for the creation of custom report point groups that shall be capable of including points from multiple controllers.

a. The number of custom reports or display groups shall be limited by the amount of available system memory.

b. Selection of a single menu item, tool (Bar) item, or tool (Bar) button shall print any displayed report on the system printer for use as a building management and diagnostics tool.

E. A time schedule programme facility for time-of-day scheduling and override scheduling of building operations shall be provided. As a minimum, the following time schedules shall be provided:

a. Weekly schedules.

b. Temporary override schedules

c. Special Holiday schedules

d. Monthly calendars.

e. Holiday scheduling system.

f. Weekly schedules shall be provided for each piece of equipment with a specific time use schedule. Each schedule shall include columns for each day of the week, as well as holiday and special day columns for alternate scheduling on user-defined days. Equipment scheduling shall be accomplished by simply inserting use and non-use times into appropriate information blocks on the spreadsheet.

F. Schedules shall be provided for each system or sub-system in the facility. Each schedule shall include all points residing within the system. Each point may have a unique schedule of operation relative to the system use schedule, allowing for sequential starting and control of equipment within the system. Scheduling and rescheduling of points shall be accomplished easily via the system schedule spreadsheets.

G. Monthly calendars for a 12-month period shall be provided that allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device or keyboard and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

4.10 Main Operators Stations

A. A main BEMS Operator Stations shall be provided (location to be finally agreed):

B. Alarms shall be relayed out of hours to designated personnel and also at a supplementary alarm printer located on site at the main reception desk as agreed with the Employer. Future relocation to the other locations shall be supported by the installed network infrastructure. The alarms shall also be relayed to the portable tablet style user devices.

C. The BEMS Operator Stations shall provide full facilities as follows:

a. Direct connect to plant processors

b. User friendly graphics package

c. Storage of trend and data history

d. Transfer of data storage to data-manipulation package

e. Web/cloud based access

f. Multi-user capability

D. The Operator Stations provided shall be a proprietary processor with the necessary ram extended memory and hard disk storage to provide adequate operating speed and data archiving to suit the system. The components shall comprise the following:

E. PC Hardware – The personal computers shall be configured as follows

a. Hard drive backup system

b. Network interface
c. CD RW Drive
d. LCD screens
e. Each LCD – 20 ” TFT SVGA Monitor 1280 x 1024 NI resolution minimum; .26 or better dot pitch and 72 Hz. minimum vertical refresh rate or max resolution; 365k colours.
f. LAN communications – Ethernet communications board 3 Comm or equal.
g. Mouse.

F. Peripheral Hardware
   a. Alarm printers (one per BEMS supervisor workstation and user designated security desk):
      i. A4 colour laser printer;
      ii. Wi-Fi communications capability.
   b. Reports printer (one per BEMS supervisor workstation, 2no):
      i. A3 colour laser printer,
      ii. Wi-Fi communications compatibility.

4.11 Software

A. All operator station software shall run under a Microsoft "WINDOWS” with facility of pre-emptive multi-tasking operating system allowing other facilities programmes to run concurrently with the BEMS. When other software is operational, the "Windows" shall be configured to allow BEMS alarms to come to the front end. BEMS software shall be modular and standard to the manufacturer and supplied as a complete package with back-up copies, manuals and operators instructions. The workstation computer shall have the following characteristics and functionality:
   a. Allow generic components to be used and shared with other OPC-compliant clients and systems.
   b. Serve as the “translation service” for the various languages used by the diverse systems with which it communicates.
   c. Support multiple clients running on both local and remote machines in the network.
   d. Control the interaction and communication between workstation applications (on clients) and the BEMS by providing standard methods for sharing and exchanging data between the BEMS and other systems.
   e. The graphics application program shall be supplied as an Active-X control and as an Active-X document server. The document server shall be able to contain other Active-X controls.

B. The BEMS terminal software shall provide the following facilities:
   a. Colour graphics displays (see under).
   b. Dynamic text displays (see under).
   c. Set point and Manual overrides with individual password levels.
   d. Alarm annunciation/acknowledgement.
   e. Alarm history file.

f. Trend graphs with up to 4 overlays with intuitive and easy to use operator scaling and colour options.

g. Instantaneous data plots of any chosen analogue parameter with choice of time interval (not necessarily trend logged).

h. Operator manning schedules and alarm re-transmission.

i. Time schedules, global/local incorporating holidays/special days.

j. Multilevel Password access, controls and set-up.

k. Printer/Plotter control to allow printer to log alarms/password entry/exit and the plotter for printing graphs/displays.

l. Automatic Archive/re-display of trend graphs, display pages and plant condition.

m. Data analysis and costing programmes.

n. Automatic configured Direct Data Exchange to third party software such as Excel.

o. Engineer's Utility giving access to outstation and operator terminal configuration.

C. The Building Energy Management System shall be configured to provide, but not be limited to, power monitoring reports, tenant/department billing reports, maintenance scheduling and management reports; and display information through universally accepted standard software (i.e. Microsoft Word, Microsoft Excel, or other compatible language driven software.) as agreed with the end user during the design development and submittal process.

D. Colour Diagrams:

a. Shall be supplied displaying the following features:

i. Each and every connected point, status conditions (Running/Stopped etc.), analogue Values with engineering parameters ('C, %RH, 1/s etc.), Output positions (% open, rpm etc.).

ii. All calculated parameters as dictated by the controls specification, (average, highest, lowest etc.).

iii. Selected optimiser switching times, (start, stop).

iv. Adjustable set points and overrides.

v. Current sequences in operation.

vi. Energy/efficiency calculations.

vii. Alarm conditions, shown high-lighted.

viii. Click-boxes to gain text panels, pre-configured graphs and other displays.

ix. To select pre-configured control actions.

x. Real time data

xi. Customised control panel

xii. Use of graphic formats

xiii. 3D symbol library

b. Sketches/diagrams showing the lay-outs and menu forms shall be supplied prior to data entry for comment by the Engineer, end users and Employer. The graphics and supporting controller software shall allow an operator to make simple changes such as manual override of status, set point adjustment and valve position subject to a suitable level of password authorization. This shall allow simple basic system diagnostic checks without recourse to engineering mode.

c. Generally colour displays shall be supplied on the basis of one per plant, with main and cross indexing/paths to allow movement between the displays in a logical manner. An exit to the head/index page shall be available from each display.

d. The correct performance of the displays will form part of the plant commissioning procedures.

e. An engineer utility allowing new displays to be created and changes made to those formatted shall be supplied. The use of this programme will be considered for ease of use and its operation shall be incorporated in the engineers training.

E. Dynamic Text Pages - Text pages shall be configured associated with each item of plant. The page shall display the current state, hours run, number of starts etc. and other conditional data. It shall also record basic data relating to the plant, manufacturer and model number. Editing the text data shall be by a simple word processor package. Text pages shall have click-pad facilities to select moves to other pages, reset counters and adjust operating overrides in the same manner as for the colour graphics.

F. Operation from graphics – It shall be possible to change values (set points) and states in system controlled equipment by any of the following methods of operator interaction:

a. Pick points –Any object shall be configurable as a pick point. In such cases specific actions can be associated with selecting the object with either the left, middle, or right mouse button:

i. Load a specific graphic.

ii. Drag/Drop to load a graphic in a selected window.

iii. Link forward or backward to another graphic.

iv. Change or toggle the value of an object.

v. Launch an executable application.

vi. In addition to pick points certain methods of changing set points shall be available and other analogue values shall be configurable implicitly as part of a graphic.

vii. Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing all drawing functions, defining all calculations to be executed as part of the graphic, defining all animations, and defining all runtime binding. It is not acceptable for separate programs to be required to do these various functions.

b. Basic drawing functions – In addition to the ability to create / edit any of the objects listed above, the following basic drawing manipulation functions shall be provided as a minimum:

i. Group

ii. Ungroup

iii. Move object to back

iv. Move object to front
v. Free rotate object
vi. Align objects
vii. Space object
viii. Copy
ix. Paste
x. Duplicate

G. The BEMS system shall be provided with a very complete symbol library containing all of the basic symbols used to represent HVAC, FIRE, and SECURITY components of a typical BEMS system.

H. Symbols shall be able to be added to any graphic display being constructed by simply dragging the symbol from the library to the graphic under construction.

I. The user shall be able to add any number of new symbols to the symbol library. Symbol generation shall include all of the abilities described for the graphic editor.

J. Any drawing—including all objects contained therein, and all animation definitions, and all action definitions—shall be able to be grouped and saved into the symbol library for re-use in graphic displays. Symbols shall be able to include implicit bindings or relation bindings, as described in the following section.

K. Trend and change of value data shall be stored within the controller and then uploaded to the trend database(s). Uploads shall occur based upon one of the following: user-defined interval, manual command, or when the trend buffers are full.

L. Alarm Management - Alarms generated by any outstation shall be processed by a main operator's terminal to sort into at least 100 alarm priorities. Each type may have any combination of the following parameters selected by the operator.

a. Alarm general/critical, outstation group, point label, location.
b. Retransmission destinations with operator time schedule.
c. Call associated plant display.
d. Store associated plat parameters on initiation.
e. Select print action.
f. Select audible alarm.
g. Log to alarm file.
h. Password level for acknowledgement.

4.12 Outstation Touchscreens

A. A full colour LCD touchscreen or panel Graphic User Interface (GUI) shall provide local textual and graphic displays of point conditions at each motor control panel/outstation and allow local set-point adjustment and manual override. Any changes shall be protected by the password system.

B. Touchscreens shall be mounted at the outstation. Touchscreens shall be supplied as follows:

a. 3.5" 320 x 240 pixel;
b. LCD full colour graphical display;
c. Full BEMS graphics;

d. Graphics customised for each outstation.

C. MCC mounted touchscreens shall be supplied as follows:
   a. 7” TFT-LCD 800 x 480 pixel;
   b. Response time 5.0 (ms);
   c. Brightness 200 (cd/m²)

D. Fixed background semi-graphical interfaces are not acceptable.

E. Each outstation and panel mounted GUI should facilitate full access to the BEMS system – subject to password restrictions.

F. The BEMS Contractor shall provide a portable operator terminal. This terminal shall be provided for full command entry, information management, network alarm management, and database management functions. The terminal shall be configured as follows:
   a. Personal Laptop Computer of reputable manufacture.
   b. 10 GB RAM (minimum) – Windows 7/8 with BEMS system.
   c. 200 MHz or Faster Clock Speed Pentium Microprocessor.
   d. PnP compliant motherboard.
   e. Wi-Fi and Bluetooth communications capability.
   f. 1 TB Hard Drive.
   g. (1) CD DVD-R/RW Drive,
   h. (1) Serial (2) USB and (1) Parallel Ports.
   i. 1 Keyboard with 83 keys (minimum).
   j. Integral 2 button Track Point or Track Ball.
   k. 12” TFT 800 x 600 resolution active matrix display with 264K colours.
   l. Two PCMCIA Type II or one Type III card slot.
   m. Microsoft Windows 7/8.
   n. Complete operator workstation software package, including any hardware or software.
   o. Original printed manuals for all software and peripherals.
   p. Original installation disks or CD for all software, device drivers, and peripherals.
   q. Software registration cards for all included software shall be provided to the Owner.
   r. Carrying case.
   s. Spare battery.
   t. External power supply/battery charger.

G. The BEMS Contractor shall provide 5 no. tablets with Wi-Fi capability and fully loaded with application software. The tablets shall come complete with:
   a. Hard protective cover;
   b. Carrycase;
   c. User manuals.

4.13 Remote Printer

A. A remote A4 size line feed printer shall be provided. It shall be fitted with fan-fold paper with a complete box of spare paper provided at hand-over. The printer shall record all out-of-hours critical and system alarms and print the event type, time and date along with text commands for action when alarms are re-transmitted by a main operator terminal. An audible alarm with reset button to silence shall be provided.

4.14 Offsite Link

A. A web/cloud based connection shall be provided by agreement to allow communication between the site and the BEMS specialist's Local Office.

B. The specialist shall be responsible for liaison and agreement of any permissions required with the Client's IT department.

4.15 Building System Controllers

A. Sufficient direct digital controllers (DDC) shall be provided to meet the site requirements.

B. The controllers shall be the current range of the intelligent controllers fully compliant with ISO 16484-5 / BACnet protocol utilising BACnet/IP and MS-TP communications.

C. The controller shall be a fully user-programmable, supervisory controller. The DDC controller shall monitor the network of any distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other DDC Controllers.

D. The DDC controller shall reside on the first tier of any network. Each DDC shall support a sub-network of a minimum of 64 controllers on the second tier network.

E. Each integration controller shall have the ability to connect to third party control systems. All programming required to implement the interface shall reside solely within the controller and the associated device.

F. Controllers shall be microprocessor-based with a minimum word size of 16 bits and a minimum program scan rate of 1 second. They shall be multi-tasking, multi-user, and real-time digital control processors. Controller size and capability shall be sufficient to fully meet the requirements of this Specification. There shall be a minimum of 2 Gb of storage for internal and external programme memory.

G. Each controller shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all second-tier controllers. Minimum of 90 day log of historical data – temperature, valve position etc.

H. The controller shall have an integrated, hardware-based, real-time clock.

I. The network communication controller shall provide at least two RS-232 serial data communication ports for operation of operator I/O devices, such as industry-standard printers, operator terminals, modems, and portable operator's terminals. Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or terminals.

J. Controller shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The network controller shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.

K. In the event of the loss of normal power, there shall be an orderly shutdown of all controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

L. During a loss of normal power a UPS system shall be provided to support each safety critical controller and PC unit connected to or controlling the BEMS system. The UPS system shall be designed to allow the normal operating functions to be maintained for a period of 3 hours. After this time the control sequences shall go to the normal system shutdown conditions.

M. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

N. The DDC controller shall provide the essential role of supervising all interactions between the connected management station and the processes which are controlled and monitored at the lower levels of the system. At the same time, the DDC controller shall manage the functions associated with the global operation of the building electrical and mechanical services, co-coordinating the direct inter-process communication for this purpose.

O. Encompassed in the above role are the real-time monitoring, data gathering and storage functions which enable the performance of the system and its connected processes to be evaluated, as well as providing the earliest warning of detected faults and breakdowns.

P. Controller Functions

a. The system controller shall be programmed using software block technology. This method shall work on the principle that each block is dedicated to a precisely defined function or "sub-function", such that the overall utility of the controller is totally flexible and can be customised to specific requirements by simply defining and linking the blocks together in the appropriate way. It should however be possible for the BEMS specialist contractor to access and edit the code behind the blocks to perform special functions in the most efficient manner as requested by the ER.

b. An overview of the general scope of the function blocks which shall be implemented is given below.

i. INPUT OUTPUT POINTS: - Software blocks shall be used to define the physical and virtual points in the upper levels of the system where they can be subsequently accessed for operational and management purposes. Failure of sensors and selection of possible default actions shall be incorporated.

ii. TIME CLOCK FUNCTIONS - Various blocks shall be available for defining additional time schedules at the system controller level based on daily, weekly and yearly events including holiday and exception.

iii. INTERLOCKING AND CONTROL - The following logical functions shall be implemented as blocks for additional interlocking functions at the system controller level:-

iv. AND, NAND, OR, NOR, "invert", "toggle/latch" - These shall be supplemented by time delay blocks for programmable ON and OFF delays, as well as blocks for supplementary control functions such as:

1. Analogue signal selection
2. Linear conversion
3. Threshold detection

v. MATHEMATICAL FUNCTIONS - The following mathematical functions shall be implemented as standard software routines for programming calculations to be performed at the system controller level:

1. +, -, /, x, MIN, MAX, AVG, SUM, ABS VAL, LOG, LN, SIN, COS, TAN, SQR, ROOT

vi. DATA STORAGE - Two distinct types of application shall be covered by blocks of this nature:
    1. Totalisation, which can be performed on analogue points for integrating measurements over their time base giving total quantities, as well as digital points for run time accumulation.
    2. Historical data gathering.
vii. ALARM AND EVENT REPORTING - As this function is best described in an overall context which includes the management level, a complete overview is provided in "Alarm Management".
viii. ENERGY MANAGEMENT FUNCTIONS
ix. The following standard software routines shall be available for implementing energy management functions at the system controller level:
    1. Adaptive Optimum start/stop control
    2. Duty cycle operation
x. GLOBAL INTERLOCKING AND SHARING - Blocks shall be available which allow the direct transfer of data between system controllers on the same network on a peer-to-peer basis. These are foreseen for global interlocking and sensor sharing purposes.

Q. Network Controller Specification

a. Hardware Specification

i.	Power	24 V AC/DC +/-10%, 30 VA, 50/60 Hz Class 2
ii.	Ambient Operating Temperatures	0 to 50 º C
iii.	Storage Temperature	- 20 to 60 º C
iv.	Microprocessor	32 bit microprocessor (ARM9/450 MHz) with real time operating system
v.	Memory	64 Mb DDR2 RAM, 32 Mbit flash memory
vi.	Backup and programme memory	2 Gb SD memory card as internal and external data
vii.	Battery back-up	2 year power fail back up, 8 year normal service life

viii. BACnet certified controller;
ix. Communication protocols:
    1. BACnet/IP;
    2. BACnet/MS-TP;
    3. BACnet/PTP;
    4. BACnet/Ethernet;
    5. Mbus incl level converter;
    6. Modbus RS485;
    7. Modbus RS232;
    8. Modbus Master;
    9. Modbus Slave;

10. Grundfos & Wilo Protocols;
11. ACSII;
12. KNX.

4.16 Outstations

A. All outstations types shall be of standard designs and have a common protocol for user configurable control and monitoring algorithms. No control/monitoring devices without soft algorithms shall be supplied. All shall include the following features:
    a. Able to operate in complete stand-alone mode.
    b. Include such programmable functions as scaling, calculations, and point, override and control action text identifiers.
    c. All Inputs/Outputs shall be constructed to give protection against mains input voltages causing damage to other than that I/O channel.
    d. Automatic restoration to full operation following a mains supply failure without recourse to any data-files held elsewhere. Have sufficient on-board battery support for on-board clock and all RAM functions to hold for at least 6 months of total power down time.
    e. Standalone lockable steel enclosures sealed to IP55 standard. All locks shall have a common key.
    f. Lap test feature;
    g. Panel mounted GUI;
    h. Mechanical structure shall be modular to allow ease of service.
    i. Satisfactory operation from 240Vac +10/-15%, 47-53Hz 1ph power supply;
    j. Outstations to come complete with all sundries required for networking and integration including power supplies, Ethernet Hubs, KNC power supplies, KNX Line Couplers etc. as appropriate. All terminals serving 24 V power devices shall be fused, knife edge type terminals. All cabling should be numbered and connections via ferrules;
    k. LED status on controller for visual indication of measured parameter is within acceptable parameter.
    l. Door mounting ability required for flush on fascia of MCC/control panel where required.

B. Digital Inputs shall have the following facilities:
    a. Capable of monitoring change of state or events from plant having volt-free contacts with a resistance as high as 4.0 (kΩ).
    b. Capable of monitoring pulse outputs from metering equipment monitoring changes in volt-free contacts to at least 25.0 (Hz).
    c. Status annunciation by LED.

C. Analogue inputs shall have the following facilities:
    a. Capable of monitoring signals directly with or without additional hardware;
    b. 0-10vdc (ii) 4-20mA (iii) 0-10,000 Ohms (iv) Digital input as volt-free contact.
    c. ADC resolution of 8 bits or better.

D. Digital Outputs shall have the following facilities:

a. Relay contacts output s.p.c.o. rated at 240 V AC, 5.0 A resistive or 24.0 V DC.

b. Status annunciation by LED or other.

E. Analogue Outputs shall have the following facilities:

a. Output 0 – 10 VDC (500 Ohms minimum load) or 0 - 20 (mA).

b. DAC resolution 8 bit or better.

F. Control and Monitoring Configuration:

a. The standard software residing in ROM (firmware) at the outstations shall be structured so that users without computer programming knowledge can configure and modify the control and monitoring strategies, (see training). A user should be able to make simple temporary set point and time schedule changes from graphics or user pages to perform simple diagnostic checks on plant performance without entering engineering or software configuration mode. An engineer's utility programme shall enable the engineer via a high level of password access to add/edit the strategies. The firmware shall be capable of the following:

i. Comparators for I/O functions including delay times for match/miss-match.

ii. Analogue input scaling and parameter identification, high/low limit alarm levels with adjustable time hysteresis and signal linearisation and inversion for thermistor characteristic inputs.

iii. Manual overrides ON/OFF and adjustments of set points and analogue constants (see passwords).

iv. Mathematical operations including multiplication, division, square root, average, maximum, minimum, greater/lesser than, and logarithmic calculations and shall typically be capable of calculating efficiency, mass flow and enthalpy.

v. Counting operations providing outputs of rate and totals over selected periods.

vi. Boolean Logic, AND, OR, NAND, NOR functions.

vii. Timer operations, advance and delay operations.

viii. Control function modules incorporating proportional, integral and derivative action and having manual override to set a default output.

ix. Output switching to raise/lower, analogue, time proportion and binary switch actuators. Adjustments shall be available to change hysteresis, respond speed, max/min levels and signal inversion.

x. Optimum Start/Stop for both heating and cooling applications. This programme shall accept variables for space temperature (calculated or direct), outside temperature, supply medium temperature and space temperature offsets, and calculate the optimum ON and OFF times for the connected plant. The programme shall have a self-adaptive algorithm to adjust the on/off time characteristic in line with calculated gain/loss constants and incorporate a self-damping feature to discount step changes after an initial settlement period. Reports shall be available indicating the conditions at any of the key event periods, start of run-up etc. A pre-start limit shall be incorporated to prevent optimization automatically starting plant very early due to system failure without alarm.

xi. A minimum of 5 independent time schedules at each outstation, each capable of 3 switching periods per day. Time schedules shall be capable of set-up as stand-alone or via global instruction in common with others. To speed set-up, facilities shall allow standard periods to be copied to each other. It shall be possible to program a full years' time schedule operations including holidays, special days, and special events. The real-time clock shall have automatic clock adjustment and be regularly synchronised with the LAN/system master.

xii. Alarm history file, used for local fault finding, shall include all plant and system alarm records. Alarms shall be generated for variables exceeding set limits, field input transducers out of range, control outputs over set limits, internal operational faults.

xiii. History logs to record direct or calculated internal analogue values. Time between recordings shall be selectable so that values can be recorded at intervals ranging from 15 seconds up to daily readings. A chart of all trend logs currently recording shall be available at each outstation showing the plot identify and recording interval.

b. Hardware Override Monitoring – DDC panels shall monitor the status or position of all overrides and include this information in logs and summaries to inform the operator that automatic control has been inhibited. DDC panels shall also collect override activity information for daily and monthly reports.

c. Local Status Indicator Lamps – The DDC panel shall provide local status indication for each binary input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

d. Surge and Transient Protection – Isolation shall be provided at all network terminations, as well as all field point terminations, to suppress induced voltage transients consistent with IEEE Standard 587-1980.

G. Outstation Sizing and Capacity

a. The BEMS Specialist Contractor shall submit a points schedule with his tender showing the physical points to be connected at each outstation site, their totals and the capacity of each I/O type available. The point schedule shall show the point(s) identifier, I/O type and input/output field device. The target installed spare capacity of I/O and software shall be 20% or better for each point type. All points required for a fully functional system to achieve the intent of the performance described in this specification shall be allowed by the specialist.

b. The inputs and outputs shown on the MCC panel drawings are indicative of the general level of monitoring requirements and control operation of the system. The tenderer shall add any additional inputs and outputs required and detail the controls and interfaces to achieve the demands of the performance specification and all BEMS equipment he proposes to supply to achieve the control performance required. A schedule of outstations shall be submitted showing the points connected to each indicating the I/O capacity supplied and the spare capacity available for future additions. The target spare capacity of I/O and software shall be 20% or better for each point type at all outstations not regarded as terminal controllers

H. (VAV/FCUs).Field Devices - A schedule of field devices shall be submitted, cross referenced to the points schedule showing the total number and specification of the device to be supplied, which shall comprise the manufacturer, model, range, accuracy, flow characteristics, working operating and static pressure ranges, all applicable to the transducer or actuator. The BEMS Specialist Contractor shall be responsible for the correct output, sensitivity and positioning of sensors. Where notional sensor positions are indicated on drawings, he shall advise any corrections required for the correct operation of his detailed design and configuration to the engineer at an early stage of the project.

4.17 Plant Control Processors

A. Main Plant Control Processors

a. The capital plant controllers shall be microprocessor based, fully software programmable, multi-algorithmic, three term DDC processors housed in the various motor control panels.

b. The processors shall be in universal (analogue or digital) input/output units of varying capacity enabling each processor location to be customised for the designed point requirements for that location plus spare capacity as required and detailed elsewhere.

c. The processors shall be fully compliant with ISO 16484-5 / BACnet protocol utilising BACnet/IP and MS-TP communications and IPV6

d. All processors shall be fully interchangeable whatever their point capacity is such that a unit with a larger point capacity may be fitted into the same base and housing as a smaller capacity unit and vice versa.

e. The processors shall be able to be fitted directly adjacent to each other with this arrangement automatically providing the necessary communications bus connections.

f. Each processor shall have output override facilities available directly through that unit, and via the communications bus, stored in EPROM. These facilities shall be built-in, access guarded and not require definition.

g. Each processor shall contain its own time base and switch times with switch time adjustment and automatic bus synchronisation between processors and between BEMS and the processor bus. The time base shall be stored in EPROM and shall be maintained within each processor such that failure of the communications link, other processors or the BEMS shall not affect the timed operations contained within any one unit.

h. The processors shall contain basic control, logic and energy selective functions. Such functions shall be resident within individual processors and selected or combined to provide strategies for the various control loops. They shall comprise of the following:

i. Control Functions not limited to:

1. Universal set point calculation.
2. Single, two and three term control. (P, PI and PID)
3. Two and three point digital control.
4. D to A, and A to D conversion.
5. Curve plotting with adaptable axis.
6. High, low and average signal selection.
7. Stepped output with delay on and off functions.
8. Hysteresis control.

9. Second and third term control component limiters.
10. Fully adjustable term parameters.
11. Fully definable output blocks with in-built delay, override and interlock functions.

ii. Logic Functions not limited to:

1. Multiple input AND, OR, NAND, NOR and EXOR blocks.
2. Digi-analogue switching blocks.
3. Multiple output ring counters.
4. Delay on, off and pulse timers.

iii. Energy Control Functions not limited to:

1. Self-adaptive optimisation.
2. Enthalpy selection.
3. Duty cycling.
4. Air quality control.
5. Demand reset control.
6. 8 independent channel, 24 hour, 7 day time clock.
7. Yearly switch functions.
8. Automatic clock synchronisation.
9. Run time totalisation.

B. Main Plant Controller technical specification, or equivalent and approved.

a. Processor memory capacity 8 bit/16 bit structure
b. EPROM for operating system and function library 128 (Kb)
c. RAM for temporary data 32.0 (Kb)
d. Resolution A/D, D/A converter 12 bit = 1/4096
e. Supply voltage 24 VAC +/- 10%
f. Frequency 50-60 Hz
g. Control accuracy 0.5% (of UeO-10V)
h. Maximum update time 1000ms
i. Transmission rate between modules and high order systems > 19200 baud
j. Number of connectable modules 16 modules per bus
k. Data storage during power failure structures and parameters 10 years' time 7 days
l. Radio interference protection accordance with VDE0871B
m. Protection class III
n. Protection standard IP00
o. Ambient temperatures - operation 10...50ºC, transport and operation -25...70ºC
p. The processors, together with their associated field interfaces shall be so designed as to provide maximum flexibility of input and output configuration.

q. On Selection of any specific interface units the following shall be considered as a minimum requirement:

i. Lamp indication shall be provided for all output signals both digital and analogue. In the case of digital signals the lamp will indicate the current state of the output.

ii. Lamp indication shall be provided for all digital input signals and active analogue input signals. In the case of digital signals the lamp will indicate the current state of the input device connected. In the case of the analogue signals the lamp will vary in intensity to indicate the magnitude of the signal received.

iii. All output signals shall have the capability of individual manual override to Hand/Off/Auto condition at interface level.

iv. All output signals shall have provision for individual externally hardwired override to maximum and minimum state. Such override to be independent of, and have priority over, any software generated signal.

C. Energy metering

a. Metering of energy consumption shall be provided from the field metering devices shown in the mechanical and electrical specifications and drawings via dedicated comms links and gateways. The units shall connect directly to the BEMS system and have the ability to store measured data from the field metering devices on communications failure.

D. Terminal Unit Controllers Technical Specification or equivalent and approved.

a. Protection standard - IP30 to IEC529 (DIN 40050)

b. Protection class III to IEC 5180

c. Noise emission - None.

E. Processing, Communications and Data Definition

a. DDC main plant controller must have the following additional functions:

i. Free selection of range and unit (dimension) of all signals (measured values, accumulated values, calculated values etc.).

ii. Free definition of manual override priorities (software) from operator terminal and/or management station (if included).

iii. Graphic documentation of application programs in function plants (structure diagrams). The signal paths must be clearly identifiable for operators without special programming knowledge. (see training)

iv. The processing speed must ensure precise and non-oscillating control of all common building services processes.

v. A self-monitoring of the processor and self-test or correct functioning of the functions must be automatic.

vi. If - for any reason - the communication between the control modules should be interrupted by wire breaks, disconnection etc., then each control module shall be able to continue to function autonomously to provide all functions including time of day based routines.

vii. Each control module shall have a real time clock with sufficient time channels which are day and date programmable to affect the control required. The clocks shall be self-synchronising when connected together on the control system communications network, thus only one clock needs setting for the whole system.

viii. The clock shall be capable of clock adjustment on the basis of either manual intervention or automatic time programme.

ix. The main plant system shall be capable of two way communication with intelligent terminal unit controllers. This will allow transmission of time, morning boost, purge and summer/winter compensation signals from main plant to the terminal unit controls. Conversely the terminal unit controls shall be capable of resetting the main plant controls by transmission of heating/cooling demand signals.

x. The transmission of signals from the process interface must be carried out via universal (analogue or digital) and digital in/outputs.

xi. The connection of the DDC units to the data bus must be provided as standard.

xii. Local operation. Each DDC unit and communication and control unit for individual room controllers where installed must be connectable to an operator terminal directly and/or remotely via a data bus. The operation must be menu driven and interactive via an intuitive and easy-to-understand keyboard and alphanumeric display.

xiii. The operating concept must be structured such that data can be accessed at individual operating levels in accordance with the associated access authority.

F. Terminal Unit Controllers

a. Each Unit Controller shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each Unit Controller shall be a microprocessor-based, multi-tasking, real-time digital control processor.

b. Point types – Each Unit Controller shall support the following types of point inputs and outputs:

i. Analogue inputs shall monitor the following analogue signals:

ii. 0-10 VDC Sensors

iii. 1000ohm RTDs

iv. PTC Thermistors

v. Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input “bouncing.”

vi. Counter inputs shall monitor dry contact pulses with an input resolution of one HZ minimum.

vii. Analogue outputs shall provide the following control outputs:

viii. 0-10 VDC

ix. Binary outputs shall provide SPDT output contacts rated for 2 amps at 24 VAC. Surge and noise suppression shall be provided on all pilot relays. Inductive loads (i.e. solenoids) shall be controlled by pilot relays.

x. Tri-state outputs shall be paired binary outputs for use as Power Close/Power Open control output contacts rated for 2 amps at 24 VAC. Surge and noise suppression shall be provided on all pilot relays.

c. Terminal Unit Controllers shall have a library of control routines and program logic to perform the sequence of operations specified in the controls narrative portion of this Specification.

d. Terminal Unit Controllers shall directly support the temporary use of a portable user terminal that can be connected to the unit via a space temperature sensor or directly at the controller.

e. All system set-points, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the unit.

4.18 Field Peripheral Equipment

A. All equipment must be readily available within one day in open market in the Republic of Ireland. This is critical to ensure there is no prolonged downtime within an acute hospital environment.

B. The field control equipment shall have the following minimum performance and physical specification:

C. Temperature Control Sensors

a. Sensors and transmitters shall be provided, as outlined in the sequence of operations, drawings and specification and as required to meet the intent of the performance controls specification.

b. The temperature sensor shall be of the resistance type and shall be two-wire 1000 ohm nickel RTD, two-wire 1000 ohm platinum RTD or PTC/NTC Thermistors to suit the application.

c. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, site installation and A to D conversion:

Point Type	Accuracy
Chilled Water	+ 0.5°C.
Room Temp	+ 0.5°C.
Duct Temperature	+ 0.5°C.
All Others	+ 0.5°C.

Table 4.2 Temperature control sensor accuracy.

d. Room temperature:

i. The unit shall be manufactured from brushed stainless steel to IP30 and shall have a de-mountable sensor housing/baseplate arrangement. The unit shall have a multi-terminal push in connector block on the baseplate to facilitate easy initial wiring and easy room unit interchange for set point/fan selector units.

ii. Storage limits shall be - 30 to 70(°C).

iii. Connections shall be non-polarity conscious.

iv. The sensing element shall be a re-active 0-10V DC device. The power source to be either supplied locally or from the processor concerned.

v. The sensor shall be suitable for operation between 0 and 50 (°C) ambient and have a linear voltage to temperature characteristic of 10 (mV/K) (50mV/K re-active). Set point reset providing a +3 degree (adjustable) range.

vi. Individual heating/cooling set point diaphragm buttons utilising an interchangeable face plate to suit the area served.

vii. Tolerance shall be matched to room condition criteria.

viii. Equipment finish and appearance shall be co-ordinated and compatible with architectural finish. Samples shall be submitted to the architect for comment.

e. External temperature:

i. As above but with clamp cable connections, housing to IP55 and suitable for ambient temperature -30 to 125(°C). Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed.

ii. The sensors shall also be provided with a solar shield. A perforated plate that surrounds the sensor element shall shield sensors exposed to wind velocity pressures.

iii. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.

f. Duct temperature:

i. The sensor housing shall be to IP43. The unit shall be supplied as sensor and mounting plate such that the sensor may be de-mounted and replaced in service.

ii. Ambient operating temperature -10 to 125 (°C).

iii. Electrical operation and characteristics to be as previous sensors above.

iv. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.

g. Terminal Unit temperature:

i. The sensor shall be provided with a 2.5 (m) flying lead connections and fittings for mounting in 13 to 16 (mm) diameter orifice.

ii. Electrical operation and characteristics to be as previous sensors above.

iii. Immersion temperature:

1. The sensor housing shall be to IP43. The unit shall be supplied as sensor and immersion pocket enabling removal of sensor without requiring drain down.

2. All sensor pockets in Chilled Water applications shall be stainless steel, suitable for local system pressure. The pocket shall be parallel.

3. Pockets shall enable immersion into the medium of no less than 60 mm. Heat conducting compound shall be used to ensure accurate transfer of process temperature to the instrument.

iv. Electrical operation and characteristics to be as previous sensors above.

v. Clamp on temperature sensors:

1. Clamp-on temperature sensors shall only be installed in applications as agreed with the engineer and shall be utilised as a method of last resort. Sensor heads shall be PT100 accuracy, and suitable for lagging over with the flying lead connecting to the electrical/junctions box.

h. Immersion sensors

i. The sensor and pocket shall be supplied as a complete assembly with the sensor unit de-mountable in service.

ii. Pockets shall be pressure rated and selected in accordance with the system working pressure.

iii. Pockets shall be mounted in a 1/2" BSP stabbing and allow easy access to the sensor for repair or replacement.

iv. Pockets shall be constructed of 316 stainless steel or brass to suit application, ensure compatibility with materials that are in contact.

v. Heat conducting compound shall be used to ensure accurate transfer of process temperature to the instrument.

i. Averaging Sensors

i. For ductwork greater in any dimension that 1.5 metre and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.

ii. For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.

iii. Capillary supports at the sides of the duct shall be provided to support the sensing string.

D. Relative Humidity Control Sensors

a. Room relative humidity:

i. The sensor shall be a solid state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination. The unit shall be identical in construction and protection to the room temperature sensor detail given above.

ii. The unit shall be an active 0-10V DC device. The power source to be either supplied locally or from the processor concerned.

iii. The range shall not be less than 20-90% RH with an accuracy of not less than +/-3% RH (+/- 1.6% RH where required to meet room condition tolerances of < +/- 7.5%).

iv. Where measurement of both RH and temperature is required one sensor capable of providing both measured conditions shall be provided.

v. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.

b. Duct relative humidity:

i. The unit shall be identical in construction and protection to the duct temperature sensor detail given above.

ii. The unit shall be an active 0-10V DC device. The power source to be either supplied locally or from the processor concerned.

iii. The range shall not be less than 20-90% RH with an accuracy of not less than +/-3% RH.

iv. Where measurement of both RH and temperature is required one sensor capable of providing both measured conditions shall be provided.

E. Differential pressure sensors

a. The unit shall be manufactured from ABS plastic to IP54.

b. The unit shall be an active 0-10V DC inductive coupling device with a linear voltage to pressure characteristic. The power source to be either supplied locally or from the processor concerned.

c. The sensor and connections shall be suitable for ambient operating temperatures between -10 and 10 (°C).

F. Differential pressure switches (air)

a. The unit shall be manufactured from ABS plastic to IP54.

b. The unit shall be a switching device with a SPDT 240V AC rated contact for minimum 1A resistive duty.

c. The individual unit measuring range shall be selected to suit the application.

d. The switch and connections shall be suitable for ambient operating temperatures between -10 and 10 (°C).

G. Low Differential Air Pressure Applications (0 to 1.25 kPa)

a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 0-10 VDC or 4 to 20 (mA) output in response to variation of differential pressure or air pressure sensing points.

b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

i. 4-20 (mA)/0-10 VDC output.

ii. Maintain accuracy up to 20 to 1 ratio turndown.

iii. Reference Accuracy: +0.2 % of full span.

H. Medium Differential Air Pressure Applications (1.25 -5 kPa)

a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:

b. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

I. Differential pressure switches (water)

a. The unit shall be manufactured to IP65 minimum and capable of withstanding a system pressure of up to 16 (Bar).

b. The unit shall be a switching device with a SPDT 240V AC rated contact for minimum 5A resistive duty. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 (mA) output signal.

c. The individual unit measuring range shall be selected to suit the application. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.

d. The switch and connections shall be selected to cope with the ambient static pressures experienced in such a high rise building.

J. Low Differential Water Pressure Applications (0-5kPa.)

a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 0-10 VDC or 4 to 20 (mA) output in response to variation of flow meter differential pressure or water pressure sensing points.

b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications.

i. 0 - 5kPa input differential pressure range.

ii. 4-20 (mA) /0-10 VDC output.

iii. Maintain accuracy up to 20 to 1 ratio turndown.

iv. Reference Accuracy: +0.2% of full span.

c. The sensor and connections shall be selected to cope with the ambient static pressures experienced in such a high rise building.

K. Medium to High Differential Water Pressure Applications (Over 5kPa)

a. The differential pressure transmitter shall meet the low pressure transmitter specifications with the following exceptions:

i. Differential pressure ranges 2.5kPa to 1000 kPa.

ii. Reference Accuracy: +1% of full span (includes non-linearity, hysteresis, and repeatability).

b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided. The sensor and connections shall be selected to cope with the ambient static pressures experienced in such a high rise building.

L. Flow switches (water)

a. The unit shall be manufactured to IP65 minimum and capable of withstanding a system pressure of 12 (Bar) and media temperature of 120 (°C).

b. The unit shall be a switching device with a SPDT 240 V AC rated contact for minimum 15A resistive duty.

c. The individual unit measuring range shall be selected to suit the application.

d. The switch and connections shall be selected to cope with the ambient static pressures experienced in such a high rise building.

M. Remote Adjustment Potentiometers

a. Where these are supplied for local override of set-point, they shall not be scaled. The scaling and range shall be achieved in software so as to allow the Owner to adjust to his design. RAP's may be mounted integrally with space temperature sensors or in their own enclosure as dictated by the specification.

N. Air Quality Sensors

a. Air Quality Sensors shall be supplied as duct mounting in the return air from the space. The unit shall be manufactured to IP43 minimum and capable of operating between 0 and 50 C with a minimum air velocity of 0.2 m/s.

b. The unit shall be an active 0-10V DC device with a linear voltage to notional Air Quality (AQU) characteristic. The power source shall be supplied locally or from the processor concerned.

c. The unit shall measure between 0-10 AQU

O. Liquid Level Switches

a. Floating type. Suitable for contents of tank. Should be capacitance type with 3.0 (m) tail suitable for medium measured. 24 V DC with 4 – 20 (mA) signal to BEMS.

b. Ultrasonic. Suitable for giving real-time measurement of fluid level.

P. Light Level Sensors

a. Outside light sensors shall have a range of 10-2000 Lux with an output of 4-20mA and be mounted in an IP67 enclosure. The sensor shall be mounted in an open position not subject to shade.

Q. Current Switches

a. Current switches shall be supplied as control panel mounted split core solid state current sensor.

b. The unit shall be a switching device with a SPDT 240V AC rated contact for minimum resistive duty.

c. The individual unit measuring range shall be selected to suit the application.

R. Fan Velocity Sensor

a. The unit shall comprise a multiple point, flow traverse probe, located in the inlet core of the centrifugal fan.

b. The unit shall be an active 0-10 V DC device. The power supply to be either supplied locally or from the processor concerned.

c. Where double width, double inlet fans are utilised a set of the fan inlet airflow traverse probes shall be mounted in each of the two fan inlets and interconnected by signal tubing.

S. Hydraulic Flow Rate and Direction Sensors

a. The unit shall comprise a flow tube using Faradays Law to sense the voltage induced by the rate of water flow through a magnetic field.

b. The unit shall be an active 0-10VDC device. The power supply to be either supplied locally or from the processor concerned.

c. Water flow meters shall be electromagnetic type with integral microprocessor-based electronics. The meter shall have an accuracy of 0.25%.

T. Duct Air Flow Sensors

a. Duct mounted air flow sensors shall be installed to provide a grid of velocity readings across the whole area of the duct.

b. The velocity pressure readings shall be averaged and the velocity sensor shall convert the flow probe average velocity pressure into a linear volume flow rate and provide a 0 – 10 (V) or 4 – 20 (mA) signal.

c. The velocity transmitter shall have the following specification:

i. Electronic velocity pressure transducer with square rooted and differential pressure signal output.

ii. Low zero drift characteristic

iii. High repeatability in low ranges

iv. Standard output signals 0 – 10 (V) 4 – 20 (mA)

v. IP54 enclosures

vi. Option of 24 (V) and 220 (V) AC power supply

vii. User calibrate

viii. LCD - Display scaled in m/s or m3/s

4.19 Field Output Devices

A. Actuators

a. Damper and valve actuators shall be electronic unless specifically indicated. Electronic damper actuators shall be direct shaft mount.

b. Modulating, two-position and spring return actuators shall be provided as required by the sequence of operations and life safety requirements. Damper sections shall be sized based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type.

c. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return and fail safe in fire mode and on power failure unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release mechanism to allow manual positioning.

d. Modulating actuators shall accept 24 VAC or VDC power supply and consume no more than 15 VA. The control signal shall be 2-10 VDC or 4-20 (mA).

e. Two-position or open/closed actuators shall accept 24 or 240 VAC power supply. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds. In addition, all fire smoke damper actuators shall be quick acting.

f. All power supplies to essential life safety fire smoke dampers shall be run in halogen free fire resistant cables compliant with BS 7846 and BS 6387 Category CWZ and the standard details of the electrical specification for this project. Fire performance shall conform to BS EN 50265-2-1 and BS EN 50266-2-4. E.g. Pirelli type FP400 or equal and approved.

B. Electronic Valve Actuators

a. Electronic valve actuators shall be manufactured by the valve manufacturer. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.

b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.

c. Modulating Actuators shall be 24 VAC powered. The control signal shall be 0-10 VDC or 4-20 (mA).

d. Two-position or open/closed actuators shall accept a 24 or 240 VAC power supply. Butterfly isolation and other valves, specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.

C. Control Valves

a. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer and shall be guaranteed to meet the heating and cooling loads, as specified.

b. All control valve/actuator assemblies shall be suitable for the system flow conditions and close against the differential pressures involved. The fan coil two port valve/actuator assemblies shall be selected by the specialist BEMS contractor to shut off against the maximum differential pressure in the particular section of the distribution in which they are installed, generally the maximum associated pump head. Body pressure rating and connection type (screwed or flanged) of the valves selected by the specialist contractor shall conform to the information in the MEP schedules and drawings elsewhere in the MEP Specification and, in particular, be adequate to cope with the high static pressures due to the nature of high rise building design and construction.

c. Chilled water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized and selected by the specialist as per manufacturer's recommendations for the given application. In general, 2 way valves serving variable flow air handling unit coils shall be sized to give a valve authority of 0.3 to 0.7 based on the actual pressure drop through the local controlled variable circuit at maximum demand. Valves (3-way and 4-way) serving constant water flow air handling unit coils shall, in general, be sized for a valve authority of 0.5 or greater, which means a notional pressure drop shall approximately equal or greater than 100% of the coil pressure drop.

d. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than 35 kPa. Valves for terminal coils shall be sized for a notional 15kPa pressure drop, but no more than a 35 kPa drop, subject always to maintaining the authority required in the paragraph above.

e. Modulating plug and seat water valves of the single-seat type with equal percentage flow characteristics shall be used for all hot and chilled water applications, except those described hereinafter. The valve discs shall be composition type. Valve stems shall be stainless steel. Diverting valves shall not be single seat.

f. Ball valves shall be acceptable for water terminal reheat coils, radiant panels, unit heaters and package air conditioning units.

g. Butterfly valves shall be acceptable for modulating large flow applications greater than modulating plug valves can control, and for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body pressure rating comparable to the local ambient pipe system pressure rating, replaceable lining suitable for temperature of system, and a stainless steel vane.

h. Valves for modulating service shall be controlled in such a manner that the valve does not suffer from drift of actual controlled position over time or during power outage. All modulating valves shall employ physical and software components that detect any drift or error and restore true valve position to within 2% of control position automatically, for instance by resetting datum on a sufficiently regular basis to prevent lack of control by position drift. Valves for isolation service shall be the same size as the pipe. Valves in the closed position shall be bubble-tight.

D. Electric Damper Actuators

a. All motorised dampers shall be provided as part of the ductwork installation.

b. The BEMS Specialist Contractor shall provide the correct number of suitable actuators for each motorised damper.

c. The BEMS Specialist Contractor shall be responsible for determining the power and number of actuators required for each and every motorised damper.

d. All modulating damper actuators shall be self-stroking and have position indictors and manual override facilities.

e. Each two position damper actuator shall have an end switch provided indicting the safe condition for interlock of the plant and for monitoring by the BEMS.

f. All two position actuators shall be spring return and set up to fail safe in fire mode on power failure.

g. All actuators shall be supplied complete with all necessary mounting brackets and linkages. The BEMS installer shall mount and stroke the actuators.

h. All power supplies to essential life safety fire smoke dampers shall be run in halogen free fire resistant cables compliant with BS 7846 and BS 6387 Category CWZ and the standard details of the electrical specification for this project. Fire performance shall conform to BSEN50265-2-1 and BSEN50266-2-4. E.g. Pirelli type FP400 or equal and approved.

E. Pneumatic Valve and Damper Actuators

a. Air operated valve and damper actuators shall operate over a range of 3 - 15 psi. The actuator/operator shall be equipped with a diaphragm operator of ample size to assure accurate positioning of the controlled device.

b. The diaphragm shall be enclosed in a metal housing for protection against dirt and damage.

c. Pilot positioner units shall be fitted to the valve actuator and all necessary interfaces supplied and installed where the control application dictates.

d. Life safety damper actions shall fail safe under spring action.

F. Electro/Pneumatic Transducers

a. Electro/Pneumatic transducers shall have an input 2-10vdc or 4-20mA giving an output of 3-15psi (0.207-1.03bar) from a 20psi supply. The transducer shall have a manual adjustment facility and be fitted with an output pressure gauge.

G. Motor Speed Controllers

a. The BEMS Specialist Contractor shall be responsible for interfacing the system outputs to the motor speed controllers, supplying any transducers or interface circuits as required.

H. Fan-out Modules

a. Where voltage driven output control modules are used to provide single or multiple switched outputs, they shall be DIN rail mounted within motor control panels, outstation cubicles or local panels to IP55 standard.

4.20 Metering

A. Flow Meters

a. Types proposed shall be chosen to suit the application, static pressure and pressure drop. The meter range and turn-down ratio shall be chosen such that the full anticipated flow range is measured within an accuracy of +/-2% or better. No positive displacement types shall be employed where safety is jeopardised by lack of flow. Flow meters shall supply a pulse output (max 25 Hz at full rated flow) or 4 - 20 (mA). All flow metering devices shall be supplied complete with any output transducers and supplied with individual over-all calibration chart. The BEMS Specialist Contractor shall advise the engineer and mechanical contractor of any isolating valves or by-pass circuits thought necessary for instrument service and maintenance of flow.

b. Meters shall be MID Certified and WRAS certified where applicable.

c. 24 V AC with data back-up facility. Units to have BACnet/M-bus communications capability.

d. In the case of the water meters installed, they shall be capable of reporting events of excess consumption and/or possible leaks:

i. Alarm reporting at the supervisor when the water passing through the meter is in excess of pre-set parameters (flow rate/duration);

ii. Ability to identify different flow and therefore leakage rates e.g. continuous, high and/or low level over set time periods;

iii. Programmable to suit the building occupier's normal usage profile and criteria;

iv. Capable of avoiding false alarms due to closed system filling and flushing exercises (chillers/boilers).

B. Local Control Panels

a. All control panels shall be factory constructed, incorporating the BEMS manufacturer's standard designs and layouts. Control panels shall be fully enclosed, with sub-panel, hinged door, and key-locking latch.

b. In general, the control panels shall consist of the DDC controller(s), display module, and I/O devices—such as relays, transducers, and so forth—that are not required to be located external to the control panel due to function. The display module shall be flush mounted in the panel face unless otherwise noted.

c. All I/O connections on the DDC controller shall be extended to a numbered, colour-coded, and labelled terminal strip for ease of maintenance and expansion. Wiring to I/O devices shall be made from this terminal strip.

d. All other wiring in the panel, internal and external, shall be made to additional line or low voltage colour-coded and labelled terminal strips. Low and line voltage wiring shall be segregated. All terminal strips and wiring shall be UL listed, 300 V service and provide adequate clearance for field wiring.

e. All wiring for every control panel shall follow a common colour-coded format. All terminal strip colour coding and numbering shall follow a common format. All wiring shall be neatly installed in plastic trays or tie-wrapped.

f. A convenience 240 V AC RCD protected socket shall be provided in each enclosure, fused on/off power switch, and required transformers.

C. Power Supplies

a. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.

i. Input: 240 VAC +10%, 50Hz.

ii. Output: 24 VDC.

iii. Line Regulation: +0.05% for 10 % line change.

iv. Load Regulation: +0.05% for 50 % load change.

v. Ripple and Noise: 1.0 (mV) RMS, 5.0 (mV) peak to peak.

b. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.

c. A power disconnect switch shall be provided next to the power supply.

4.21 Documentation

A. Wiring Diagrams

a. The appointed BEMS Specialist Contractor shall prepare wiring diagrams, physical and fascia layout, field wiring installation drawings and details, drawings which, when completed, shall be forwarded through the contract for comment.

b. The wiring diagrams shall indicate the cable type and the number of cores required for each item.

c. Wiring diagrams shall be produced in sufficient time to enable the wiring to be implemented within the building programme.

d. The BEMS Specialist Contractor should note that no manufacture of equipment shall commence until written comments have been given by the Engineer.

B. Control Strategy Design Intent

a. The BEMS Specialist shall prepare a written detailed description of the proposed control strategy for each system, including control, logging, graphics and alarm parameters, before application software is commenced, for comment and agreement by the Engineer and the proposed end-user.

C. Operating and Maintenance Manuals

a. The manuals shall include the following information:

i. Wiring and fascia diagrams. Wiring diagrams must include terminal numbers on connected plant, whether supplied as part of mechanical works or by others. In addition, to ease reading of wiring drawings the terminals on relays and contractors should be 'grid referenced' to the area of the drawing showing the circuit through those terminals.

ii. Field wiring installation drawings, showing routing and destination of all wiring.

iii. Local Area Network (LAN) schematic.

iv. Control strategy document.

v. Control logic diagrams.

vi. Location of all panels, outstations and control devices.

vii. Control, alarm and limit for each control device.

viii. Alarm schedules, destinations of alarms.

ix. Copies of all demonstration, monitored/trend logs.

x. All test/calibration certificates.

xi. Technical details of all panel equipment, outstations, controllers, control sensors, etc.

xii. Suggested spares list.

xiii. Copies of BEMS system graphics as a record of the as installed schematics

xiv. A simple user guide, specific to this project, which shall explain simply and clearly in layman's not engineering or technical language how to use the controls and in particular the use of interfaces/controls. The document shall be in English and Arabic and shall enable a non-technical occupant to set the system up easily to achieve desired conditions. A summary with basic tips for successful operation and very basic troubleshooting guidance shall be included. The aim is to enable an occupant to get the best from the system and the room controls in particular and rectify simple faults such as (but not exclusively) power off, set point too high too low etc. without external help.

D. Application Software

a. Two copies of the as installed application software on compact disk shall be handed over at Practical Completion. One hard copy print of software. Any changes during the next 12 months shall be recorded and updated copies shall be provided.

E. Updating

a. The installer shall allow for the full updating of the O&M Manuals at the end of the 12 months after Practical Completion, following any modifications to the control systems required and for providing two further copies of the revised application software. The Digital Safety file shall be kept up to date.

4.22 Software and Equipment Maintenance and Updates

A. The BEMS Specialist Contractor shall provide software maintenance for one year after PC.

B. The BEMS Specialist Contractor shall provide a guarantee that the systems and equipment that he provides will either continue to be produced and/or be maintainable for a period of at least 10 years. Elemental equipment substitution is accepted for peripheral items, but not for the microprocessor based equipment.

C. The BEMS Specialist Contractor shall provide maintenance of the complete controls installation for one year after PC. Include in the tender for maintenance to include:

a. Help desk back-up for the user.

b. Call out service.

c. Regular service visits.

d. Re-tuning of control loops to cope with seasonal and occupancy changes.

e. Re-calibration of panel components every 6 months.

f. Re-calibration of field sensors and actuators every 6 months.

g. Replacement of all defective equipment during the maintenance period.

h. Software updates.

5 Execution

5.1 Installation of HVAC Control System Wiring

A. All conduit, wiring, accessories and wiring connections required for the installation of the Building Energy Management System, as herein specified, shall be provided by the BEMS Specialist Contractor.

B. All analogue input wiring shall be twisted shielded pair or multi-core minimum 0.55 (mm^2) CSA or as specified by the BEMS equipment manufacturer. All system analogue output wiring shall be twisted shielded pair/3-wire as required, minimum 0.55mm^2 CSA or as specified by the BEMS equipment manufacturer. All internal panel device wiring for binary outputs and pilot relay shall be minimum 16 gauge wire.

C. All field control wiring shall be installed within a dedicated trunking/conduit system or armoured cables routed on a dedicated tray. Similarly, all power wiring is to be routed in a tray system or contained within a trunking system.

a. ELV wiring not installed in conduit shall be supported every 150 (mm) from the building structure utilising metal hangers designed for this application. Wiring shall be installed neatly and tidily in parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements. Exposed wiring shall only be allowed in concealed accessible locations.

b. ELV control wiring and 24VAC can be run in the same conduit and if allowed by manufacturer of specific equipment used. Power wiring 240VAC and greater must be in a separate conduit.

c. All wiring in plant rooms shall be in conduit and trunking. Minimum control wiring conduit size 20 mm.

d. Visible wiring and equipment in occupied spaces will be co-ordinated and conform to architectural requirements.

e. All power supplies to essential life safety fire smoke dampers shall be run in halogen free fire resistant cables compliant with BS 7846 and BS 6387 Category CWZ and the standard details of the electrical specification for this project. Fire performance shall conform to BS EN 50265-2-1 and BS EN 50266-2-4.

5.2 Location of Equipment

A. All equipment shall be sited in such a position that it can be easily maintained with adequate access. Control panels are not to be sited adjacent to escape routes. Ensure that a minimum of 1,000 mm is provided for access at the front of each control panel.

5.3 Equipment Identification

A. All items of automatic control equipment are to be identified. Use engraved laminate labels (black lettering on white background). BEMS Specialist Contractor to provide a complete

schedule of control devices with the proposed coherent and unique labelling, system and item number, for comment by the Engineer.

B. Identification Standards

a. All controllers shall be identified by a plastic engraved nameplate securely fastened to the outside of the controller enclosure.

b. All local control panels shall be identified by a plastic engraved nameplate securely fastened to the outside of the controller enclosure.

c. All field devices shall be identified by a typed (not handwritten) securely attached tag label.

d. All internal panel devices shall be identified by a typed label securely fastened to the backplate of the local control panel.

e. All power and control wiring shall be identified by a number, as referenced to the associated control diagram, at each end of the conductor or cable. Identification number shall be permanently secured to the conductor or cable and shall be typed.

C. Digital Controller Systems

a. Each system will be provided with its own dedicated direct digital controller or application specific controller. Mechanical systems such as AHUs, FCUs or Packaged system shall not be controlled from more than 1 application specific controller.

b. Systems that use second tier controllers as point expansion for system controllers shall only be allowed under when the I/O points are directly controlled by the CPU of the local application specific controller.

D. Input Devices

a. All Input devices shall be installed as per the manufacturer's recommendations. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, duct smoke detectors, air flow stations, etc.

b. Low Differential Air Pressure Applications (under 1.25 kPa) Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing contractor and Owner permanent easy-to-use connection. Provide a minimum of a NEMA 1 housing for the transmitter. Locate transmitters in accessible local control panels wherever possible. Except on FCU applications.

c. Medium Differential Air Pressure Applications (1.25 to 5.0 kPa.) Mount stand-alone pressure transmitters in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with hi and low connections piped and valved. Air bleed units, bypass valves and compression fittings shall be provided.

d. Medium to High Differential Water Pressure Applications (over 5 kPa): Mount stand-alone pressure transmitters in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with hi and low connections piped and valved. Air bleed units, bypass valves and compression fittings shall be provided.

e. Building Differential Air Pressure Applications (-250 Pa to +250 Pa): Mount pressure transmitter in the local control panel. Transmitter's exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by

wind. The interior tip shall be inconspicuous and located within a representative central space.

f. Air Flow Measuring Stations: Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork. Stations shall be installed in strict accordance with the manufacturer's published requirements.

g. Water Flow Monitoring Stations: Water Flow Monitoring Stations shall be installed in strict accordance with the manufacturer's published requirements.

h. Outside Air Humidity Sensors: Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealtite fittings and stainless steel bushings.

i. Outside Air Sensors: Outside air sensors shall be mounted on the North wall to minimise solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air temperatures accurately. Sensors exposed to solar radiation must be installed with adequate solar shields or sufficient other protection to prevent solar gain distorting the values measured. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate surrounding the sensor element.

j. Duct Temperature Sensors: Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate. For ductwork greater in any dimension that 1.2m and/or air temperature stratification exists such as a mixed air plenum, utilise an averaging sensor with multiple sensing points.

k. The sensor shall be mounted to suitable supports using factory approved element holders. For large plenum applications such as mixed air temperature measurements, utilise a string of sensors mounted across the plenum to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 3-metre-long segment.

l. Space Temperature Sensors: Shall be mounted at 1.5 metre above the finished floor. Temperature sensors installed in public areas shall be provided with lockable covers to prevent tampering.

m. Low Temperature Limit Switches: Mount element horizontally across duct in a serpentine pattern insuring each square metre of coil is protected by 1 metre of sensor. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.

n. Differential Pressure Status Switches: Provide complete installation kit including; static pressure tops, tubing, fittings and air filters. Provide appropriate scale range and differential adjustment for intended service.

E. All output devices shall be installed per the manufacturers' recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, etc.

F. All control actuators shall be sized capable of closing against the maximum system shut-off pressure, for two port valves the appropriate pump head. The actuator shall modulate in a

smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.

G. Control Valves shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 0.35bar. The maximum pressure drop for steam applications shall be 0.5bar. All valves shall be selected to withstand the static pressure of the circuits in which they shall be installed.

H. Electronic Signal Isolation Transducers: Whenever an analogue output signal from the Building Energy Management System is to be connected to an external control system as an input (such as a chiller control panel) or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems.

6 Commissioning, Testing and Handover

6.1 Warranty

A. Material: The BEMS Control System shall be free from defects in material and workmanship under normal use and service. If within three years from the date of practical completion in whole or in part any of the equipment herein described proves defective in operation, workmanship or materials, it will be replaced, repaired or adjusted at the option of the BEMS Specialist Contractor free of charge.

B. Installation: The Control System shall be free from defects in installation workmanship for a period of one year from the date of practical completion in whole or in part. The BEMS Specialist Contractor shall, free of charge, correct any defects in workmanship within one week of notification in writing by the Employer/Engineer.

6.2 Commissioning

6.2.1 General

A. The BEMS Specialist Contractor shall be responsible for the full commissioning of his system and any other controls equipment supplied by him.

B. All safety interlocks, overrides and fail-safe conditions are to be operational prior to starting the plant. Demonstrate as approved by the Engineer prior to starting plant in BEMS auto mode.

C. Fault conditions for all critical alarms, safety devices and control interlocks shall be simulated and proved effective as soon as practical once BEMS control mode is selected.

D. Sensors shall be checked to ascertain accuracy within limits, pressure switches checked for switch points and hysteresis. Humidity sensors shall be checked for accuracy using a wet/dry bulb thermometer.

E. All the necessary test equipment and materials used in commissioning shall be supplied by the BEMS Specialist Contractor. All test equipment shall have valid test certificates.

F. Trend graphs shall be provided to demonstrate the stable control of all of the plant. Changing control set points or if necessary simulated inputs shall be employed to check stability over the design environmental range.

G. The BEMS Specialist Contractor shall allow for sufficient additional full day returns, minimum but not limited to six days, by his commissioning engineer to revisit, check and re-tune the system at a later date (6 months and 11 months after hand-over) or other time agreed with the Engineer/Employer. He shall check and adjust operational parameters and re-tune any control as maybe required by change in the seasonal load conditions or bedding-in of the plant to restore correct functionality.

H. The BEMS Specialist Contractor shall include in his tender an allowance for system tuning via auto-dial or visit to check correct operation of all plant items which may exhibit changes in stability due to settling in or seasonal conditions.

I. Detailed commissioning documentation and schedules shall be submitted for comment by the Engineer during the design phase showing each plant item, input and output point, interlock and control algorithms, and the stages of checks and commissioning required. Each cleared item to have date and engineer reference. Completed copies shall be submitted to the

Engineer for comment prior to acceptance testing. A complete set of the commissioning documentation is to form part of the system documentation.

J. Once any item of plant is commissioned and left running to the dictates of the BEMS, appropriate documentation showing the overrides, control and software configuration shall be available on site at all times.

6.2.2 Integrated Service Tests

A. BMS specialist contractor shall coordinate and attend mock-ups with all 3rd party systems that require Serial integration with the BEMS. The contractor shall ensure that he, the BEMS vendor and any vendor who's system is to be integrated with attends in full for all Mock ups, design meetings, workshops etc. to agree and test the relevant interfaces before equipment is procured and sent to site.

6.2.3 Witnessing

A. 30% of total points both hard and virtual to be witnessed. If failure rate in excess of 10%, 100% witness test to be undertake.

6.3 Demonstrations and Operation Trials

6.3.1 General

A. In addition to Employer/Engineer demonstrations and commissioning works, the following shall be monitored (by use of the BEMS trend logging facility and where necessary by electronic data loggers) on a 15 minute interval basis 24 hours/day for a 7 day operational week both for winter and summer periods.

   a. Outdoor air temperature and humidity;

   b. Outdoor atmospheric CO_2;

   c. Supply and return air temperature for the following;

   d. All AHUs

   e. All LPHW and CHW water flow and return temperatures (all primary and secondary circuits);

   f. FCU on and off coil temperatures;

   g. All space temperatures and air quality sensor values;

   h. All air volume supply rates.

B. Schedule the operating parameters and time schedules that have been set into the control systems during the two trial periods to enable the data log results to analyse.

C. Print out on a daily basis, graphs of all points monitored and mark-up these graphs with the control set points and design limits where applicable and submit all of these graphs and schedules to the Engineer and Owner for comment.

D. Enclose the data log graphs and operating parameters scheduled as part of the O&M Manual at handover of the building. It is accepted that at handover, only one of the two trial periods will have been completed and consequently that the second set of results will be recorded and enclosed at a later date.

E. The object of the trials is to demonstrate that the monitored systems perform as required, including scheduled starts and stops, for a 7 day period without requiring adjustment of any control set points or changing of any equipment. It follows, therefore, that sufficient pre-trials

test runs must be carried out by the installer, such that they are confident that the systems and their controls will operate satisfactorily during the trails periods.

F. Should any part of the system or its controls fail during the trial or require adjustment the Engineer shall decide whether the trial shall be void and restarted.

G. The benefit to the BEMS Specialist Contractor of successfully carrying out the above detailed trial is that he shall have proved that the systems work as required.

H. It is necessary to check the calibration of all sensors prior to starting the trial to prevent abortive work.

I.A signed certificate detailing the calibration check results for each sensor shall be provided by the BEMS Specialist Contractor.

J. Copies of calibration certificates for all test equipment used shall also be provided.

K. The position of each data logger around the building shall be agreed in advance of the trials commencement with the Engineer. Notwithstanding the above, all data loggers must be placed at working plane level (0.9 m from finished floor level) and be sited away from the influence of draughts or direct solar gain.

L. The complete set of graphs shall be referenced, indexed and included as part of the handover documentation in their own clearly identified ring file. All sensors and test equipment calibration certificates shall also be included in this document.

M. Compact disk(s) containing all of the trial data shall be included with the handover documentation.

N. Should any part of the system require alteration or adjustment during the trial then the period shall be extended to provide the required time after the alteration/adjustment.

O. Any compromise to that trial period extension shall be at the discretion of the Engineer.

P. The controls contractor shall issue a report based on a sampling of any VAV and FCU controller calculated loop performance metrics. The report shall indicate performance criteria, include the count of conforming and non-conforming boxes, list the non-conforming boxes along with their performance data, and shall also include graphical representations of performance. The sampling shall take place after completion of Test and Balance, when design cooling and heating media have been available and occupied conditions approximated for five consecutive days.

6.3.2 Supervisors

A. Demonstrate to the satisfaction of the Employer/Engineer that alarms handling, passwords, acknowledgements, peripherals, graphics, automatic data storage, back door access, alarm and graphics report times and alarm masking all function correctly at each Building System Operating Station.

6.3.3 Repeatability Test

A. Comprehensively repeat and test transmission of alarms to supervisors and generate alarm faults to demonstrate to the satisfaction of the Engineer that the communications system is reliable.

B. The object of this test is to demonstrate that the communication system operates without fault at handover. The benefit to the BEMS Specialist Contractor of successfully carrying out the above test is that he shall have proved that the system did work as required. Notwithstanding the above, the BEMS communications network is the sole responsibility of

the BEMS Specialist Contractor and he shall immediately rectify any faults which are detected during the defects liability period.

6.4 Operation, Training and Maintenance

A. The BEMS Specialist Contractor shall provide a suitable member of the site BEMS installation and commissioning staff and the project BEMS and Planned Preventative Maintenance (PPM) system engineer, to attend the site and assist the Owner in the operation of the BEMS system for a period of two weeks after system handover, and for a further period of one week to be arranged with the Employer during the first year after system handover.

B. The BEMS Specialist Contractor shall arrange and allow for all associated costs, for the elected Employer's representatives (allow for five number staff) to undertake training in the use of BEMS.

C. The contractor shall include for 1 day of support for 4 weeks post PC and a total of 100 hours of support within the first year to the Rotunda Hospital technical services team. Hours are to be confirmed by the Rotunda Hospital at their discretion. This is to provide any training or assistance deemed necessary.

D. The training shall be phased to ensure a full understanding of the system:

- Phase 1;
- Phase 2;
- Phase 3;
- Phase 4.

E. The first phase shall be the provision of a basic set of literature on the principles of the BEMS method of control, specifically for the manufacturers' equipment, BEMS set-up and PPM capabilities.

F. The second phase shall be the provision of all of the manuals by the BEMS Specialist Contractor in the word processed format, together with the drawings and methods of

operation to allow the representatives to familiarise themselves with the features of the system installed.

G. The third phase shall be a course each provided with simulator terminals and with hands on adjustment and appraisal of the control elements used within the manufacturers work or other suitable location locally. The course content shall include:

   a. System hardware.
   b. System software.
   c. The operator interface.
   d. Access routines
   e. System hierarchy and structure.
   f. Communications.
   g. Alarms.
   h. Trend logging.
   i. Graphics creation and editing.
   j. Programming language.
   k. Hard and soft points.
   l. Control loop.
   m. Edit facilities.
   n. Network theory and equipment.
   o. Outstation programming.
   p. BEMS input and manipulation.
   q. PPM programming and interfacing to the BEMS.

H. The fourth phase of the training shall be Site based with a familiarisation tour of all the BEMS and PPM facilities that are unique. This shall be undertaken with the "as installed"

information and final manuals and incorporate any field adjustment and maintenance activities that are required.

I. The final phase of the training shall be on Site with all user activities being demonstrated and with each representative having a keyboard tour of the Site facilities with opportunity provided to have supervised access to all of the system functions.

J. In order to support good facilities management sufficient training shall be provided to enable a trained operator to, as a minimum:

a. View equipment status

b. View and acknowledge alarms

c. Adjust optimised time clocks and calendars

d. Adjust set points and control parameters

e. Investigate calculated values

f. View plant hours run data

g. Chart energy usage from the meters

h. Create tenant utility bills

i. Create and view long term trend Logs of controlled parameters in particular the temperature and humidity in areas.

J The Contractor shall allow for 2 No additional full day presentations and/or training days for new users of the system within a one year period after handover.

6.5 Seasonal Commissioning

A. The BEMS specialist shall allow for seasonal commissioning of the BEMS system over a 12 month period post practical completion.

B. Seasonal commissioning shall comprise the performance evaluation of the HVAC systems under full and part load conditions. In particular, peak heating and cooling seasons as will as part load conditions during spring and autumn.

C. Seasonal commissioning shall also take into account building use and occupancy profiles together with maintenance activities undertaken by plant and equipment suppliers and systems specialists during that period.

D. Post occupancy reviews and evaluations shall be carried out as part of the seasonal commissioning exercise.

7 Maintenance

7.1 Scope

A. The first two years maintenance of the BEMS system forms part of the scope of the proposed works and is to be included within the tender return.

B. All maintenance shall be completed in accordance with CIBSE 2023 Maintenance Engineering and Management, SFG20 and as per manufacturer's recommendations.

Appendix A: BEMS Control Point Schedule

A. Refer to the attached Section A BEMS Points List.

Appendix B: Sample Graphics

A. Refer to the attached Section B BEMS Sample Graphics.

Appendix C: Rotunda Hospital BMS Screen Shots (September 2025)

A. Refer to the attached Section C BEMS Screen Shots.

Appendix D: Site Photographs

A. Refer to the attached Section D BEMS Site Photographs.