ASHP, on floor AHUs, package AHU, smoke extract, PHE, power monitoring, openable windows.

October 2022

Fairlawn Controls

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Content

Appendices

1. AUTOMATIC CONTROLS AND BUILDING MANAGEMENT SYSTEMS

This document shall be read in conjunction with all other sections of the Contract preliminaries, Technical specifications, Architectural, structural and services drawings.

This section describes the Automatic Control System-Building Management System and is equally applicable to any automatic control system provided either as the BMS, stand-alone controllers, package controllers or the energy management system.

The Contractor shall be responsible for the automatic controls and BMS systems associated with the project. They shall employ an automatic control specialist for this section of the works.

The project will be constructed within an existing building that will have been stripped by others.

There shall be a number of discrete automatic control systems provided which shall be capable of operating as a standalone solution that are integrated onto a site wide BMS for general review and management. The stand-alone automatic control systems shall include office ventilation AHUs, the office fresh air air handling plants, the heat pumps, the domestic hot water system, the smoke control systems, the firefighting smoke lobby control system, the window and blind control system and the VRF/DX air-conditioning system. These control systems shall be constructed to the minimum standard described in this control section and generally as described in the mechanical services specifications.

The project will include enhanced control system for a smart enabled development.

This portion of the work is a Contractors Design Proposal, information provided in this document is the minimum level required for materials, workmanship and plant operation.

1.1 Document Note

For the easy read of this specification the scope and remit of the specialist automatic controls suppliers is described. However, the Contractor shall be responsible for the entire works and within reason the remit of various specialists is interchangeable.

The completed works shall be in line with the project specifications with regards to operation, standards of materials and workmanship, irrespective of who supplies the works.

As an example, this document assumes that the power boards for the plant and equipment and heat meters are provided by the BMS specialist however, these can be by the electrical contractor or perhaps the specialist plant provider.

Where the Contractor elects to provide controls equipment other than through the BMS specialist and in particular this probably relates to control valves, heat meters, energy meters, motor drive speed controllers, inverters, then this equipment shall be selected in conjunction with the BMS specialist. The BMS specialist shall provide full attendance whenever these 3rd party control devices are set to work and commission. Similarly, the specialist suppliers shall provide full attendance when integration of the equipment with the BMS is required.

All controls contractors shall comply with the requirements of the specification with regard to workmanship materials and standards. Whenever the term BMS is used this shall be equal applicable to every specialist automatic controls supplier.

This specification assumes that the AHU specialist shall provide all necessary installation from the AHU out to the fan tile units and configure and provide all controls necessary. If the AHU specialist is a supply and commissioned service only then the contractor shall include all necessary costs associated with cabling both provision and installation and the demonstration of this to the AHU specialist.

1.2 Smart Building Integration

The client has a desire to provide a smart building environment for both the occupier and the FM team. Generally, the occupier experience such as desk booking, find a room, printer management, cycle rack booking will be carried out by separate specialist and described in the smart building section of the specification. The BMS will provide all normal controls, user interfaces, BMS head end supervisor however specific items shall be made available to the smart system via a BACnet or MQTT.

To facilitate Smart Building Integration, it is necessary that a naming convention is agreed in the first instance this shall be project Haystack as incorporated within the Niagara platform.

The BMS specialist shall provide two JACE 8000 controllers each licensed for 10,000 points. It is not envisaged that 20,000 points are required just that the controllers shall be limited to perhaps 80% capacity each.

To provide air quality measurements that are generally in line with the Well standards the BMS specialist shall provide separate air and room quality monitoring via a Modbus device wired to the managed switch in the BMS controller. The device of which there shall be up to 2 per tenant should include: temperature, RH, CO2, PM 2.5, TVOC. The device shall be similar to a Kaiterra SenseEdge Mini.

2. PROJECT SERVICES OVERVIEW

The project is the development of the building to accommodate separate tenants on each floor. The floors are generally open plan offices fitted out to Cat A standard.

Air-conditioning is generally provided by on floor air handling plants that supplies air via pressurised floor plenum to local fan tiles complete with 2 position dampers, variable speed fan and where appropriate electric reheaters. The office air conditioning system that communicates via Modbus shall be provided with Modbus to BACnet/IP interface for connection to the sitewide BMS.

Fresh air to the office air handling plant is provided from basement air handling plants that are provided as a package with : heat recovery systems, DX heating and cooling coils and as appropriate and electric preheater. These systems provide tempered air to the air office air handling plants via variable volume boxes that are controlled by the sitewide BMS generally on CO2 control space/return air sensing. The packaged air handling plants shall have BACnet/IP interface for connection to the sitewide BMS.

The office is provided with mixed mode ventilation using openable windows mounted at high level on the office floor plate. The windows are provided with intelligent actuators connected to a KNX network and a floor master controller, power to the windows is provided from a local powerpack. The BMS shall be provided with a BACnet/KNX gateway for communication to the window floor master controller through which the BMS shall call for the windows to open dependent upon the outside air conditions. At low level on the office floor plate manual operated windows are provided. These are provided with magnetic proximity switches that are monitored by the BMS. Solar shading is provided as appropriate and controlled and managed by the site wide BMS.

The windows and blinds are controlled by the sitewide BMS and when in the mixed mode condition, the office fan tiles systems set back to full recirculation without heating or cooling.

Ventilation to the basement, the toilets and the twelfth floor conference area is provided via packaged air handling plants mounted in the basement and roof as appropriate. These air handling plants are provided with heat recovery, DX cooling/heating and electric preheater is as appropriate. The integral control panels shall be provided with BACnet/IP interface for connection to the sitewide BMS.

Low Temperature heating and chilled water systems are provided from secondary circulation pumps in the basement with 4 pipe air source heat pumps mounted on the roof, the ASHP shall be provided with the specialist provided control system. The secondary pumps circulate water to the on floor air handling plants and generally operate at variable volume to suit the system demands.

The LTHW and CHW primary pump sets are enabled and speed controlled by the ASHP integral control system although, the BMS receives signals and then enables pumps as necessary.

The bin store is ventilated by a mechanical ventilation heat recovery plant complete with electric heater battery that is controlled and managed by the sitewide BMS.

Smoke extract is provided from the basement by two sets of run/standby axial flow fans. These are controlled and managed by the sitewide BMS and operate through hardwired commands.

The LV room, UPS and management suites are provided with VRF type heating cooling as appropriate. The VRF specialist shall provide all interconnecting networks and controllers between the fan coil units and the external air cooled condensers. The BMS specialist shall provide a high-level interface between the VRF system and the BACnet BMS system.

Heating and cooling is provided to the mezzanine offices using 4 pipe fan coil units the controls provided by the BMS specialist.

Underfloor Heating is provided in the shower areas. The pumps and valves shall be controlled and monitored by the sitewide BMS.

Trench heating and cooling is provided in the entrance hall with radiators on the staircase and in the cycle store

The domestic water systems include portable and nonportable tanks and booster sets. These shall be provided with integral controls and safety interlocks by the specialist supplier and monitored by the sitewide BMS.

The rainwater, grey water systems shall be provided with power controls and safety interlocks by the specialist supplier. These shall be monitored by the sitewide BMS.

The HWS system shall be generated by a water source heat pump controlled and managed by the sitewide BMS.

The chilled and heating system shall be provided with MID approved heat meters that shall be networked by the BMS specialist.

The electrical system is provided with switchboards, distribution boards and a central UPS. The switchable breaker status and the central UPS shall be monitored by the BMS.

The switchboards, distribution boards and MCCs shall be provided with MID approved electrical meters that shall be connected by the BMS specialist to the sitewide metering system.

The BMS specialist shall provide the energy monitoring system for both fixed and virtual meters such that energy for all systems can be evaluated and plant coefficient of performance determined.

The BMS specialist shall provide the tenant billing system that shall make use of fixed and virtual meters and incorporate energy used in central plant as well as directly measured at the distribution boards and the on floor air handling plants.

2.1 Automatic Controls Outline Work Scope

The contractor shall develop the design, supply and install set to work, test, commission and handover the completed automatic controls systems for the entire project. This shall include but is not limited to: the functional design specifications, control panel design, plant description of operation, design and selection of controls instruments and actuators, supply of heat meters, main plant controllers, specialist AHU controllers, fan tile controllers, fan coil unit controllers, user interfaces, software, firmware and hardware, control and starter panels, all power and controls wiring along with carrier systems, setting to work commissioning and handover.

The office AHU specialist shall provide all controls and safety thermal interlocks for both the fan tile units and the office air handling plants (CAM units).

The office AHU specialist shall provide interconnecting networks between the fan tile units and the associated air handling plant. The AHU specialist shall provide interconnecting networks between the individual tenant AHUs and provide the single local user interface for each tenant with a further display device for each individual AHU (CAM). The AHU specialist shall provide BACnet/IP connection that shall be connected to the converged network to form a site wide AHU/BMS network.

Fresh air to the on floor plantrooms, the basement and the toilet systems is provided from specialist provided AHUs with integral controls and high-level interface to the BMS.

The air source heat pump specialist supplier shall provide the complete control system for the sequence control of the air source heat pumps and the control of the primary heating and chilled water circulation pumps. The BMS shall control the secondary heating and cooling circulating pumps.

The staircase fire fighting lobby smoke control specialist shall provide all power, controls and safety interlocks and integration to the sitewide BMS.

The domestic hot water system shall be generated by water source heat pumps with integral safety and thermal interlocks with the circulating pumps controlled and managed by the BMS.

Local cooling and where appropriate heating is provided to the back of house management and plant room area is utilising DX and VRF systems with rooftop mounted air source heat pumps. The system will provide with integral controls and high-level interface to the BMS.

The smoke damper control specialist shall provide control panels interconnecting networks and a high-level interface to the sitewide BMS.

The window control system shall be provided by specialist supplier with Installation and management by the BMS specialist.

The solar blinds are provided by specialist supplier controlled and managed by the BMS specialist utilising a virtual solar map and external light level sensors.

The converged network shall be provided by a specialist generally running BACnet/IP with managed switches and spanning tree protocols. The network shall terminate within or alongside the packaged AHU controllers, the BMS control panel enclosures, lighting controllers, CCTV and the like with sufficient RJ 45 sockets.

The BMS specialist shall provide and install all networks downstream of the master controllers such as BACnet/MSTP for the fan coil units, inverters, air quality sensors and the VAV, Modbus for the electrical metering and ASHP monitoring, M-bus for water metering and BACnet/MSTP for heat meters.

The BMS specialist shall install the free issue window control components complete with all interconnecting network connections and control cable termination, the powerpack shall be installed by the electrical specialist.

The scope shall incorporate a smart building services ready solution which shall generally be through two JACE 8000 fully licensed each with 10,000 points for BACnet/IP and MQTT communication to a future smart system. To accommodate this the control specialist shall develop a naming convention based on Project Haystack.

The scope shall include the implementation of the energy monitoring system that should include automatic monitoring and metering targets and the development and implementation of dynamic dashboards. The EMS is an integral part of the BMS although separate EMS network shall be provided that terminate at BMS control panels.

The scope shall incorporate the development and implementation of the landlord/tenant billing system. The BMS specialist shall provide a secure hosted server on the site for the purpose of billing and allowing tenant access to billing data.

The scope shall include the BMS server hardware and software fully configured with dynamic graphics and management interfaces. The system shall allow web access from any web browser either connected directly to the network or via Wi-Fi connectivity.

The AHU specialist shall include all necessary hardware, firmware, software, configuration, testing and commissioning and integration with the sitewide BMS.

The controllers may be manufacturer specific web enabled devices; however, BACnet/IP is the preferred solution with Niagara product where appropriate for interfaces to third party equipment. The controllers shall communicate BACnet over IP and BACnet MSTP. These shall also include wireless device for local near field connection allowing full access to the controller and the appropriate site wide access. The submodules may be from any BMS specialist provided supplier.

The scope shall incorporate system test plans, stand-alone and integrated system testing, system handover packages and demonstration of the works to the client and the client representatives.

The scope shall include functional design specifications, description of operations, plant and equipment schedules, cabling schedules, control panel wiring diagrams, plant interface schedules, topography, plant and equipment location drawings, cable route drawings and operating and maintenance manuals.

The BMS & Automatic Controls specialist will size, provide and install all power and controls wiring and any necessary controls, power wiring and carrier systems between; control panels, outstations, and all field mounted controls instruments and actuators and other equipment BMS interfaces.

The BMS and automatic controls specialist shall provide all necessary control panels generally to a minimum standard of: form 4A type 2 for large mechanical service loads, form 3B type 2 for life safety systems, form 2B type 2 for standard systems and form 1 for control panels.

It should be noted that the supplier of power boards and any subsequent power wiring shall be the responsibility of the contractor who shall size all LV components such as protection devices, cable systems, cable sizes and carrier routes.

2.2 Scope

2.2.1 Extent of Work

The technical work scope for each automatic control specialist shall be determined by the main contractor. The following is given for guidance:

The BMS and automatic controls specialists shall design, supply, install, set to work, test and commission the complete automatic control and building management system required to serve all building services installations specified, in the project specification, unless specifically stated otherwise hereafter. The scope shall incorporate all control outstations, software, system configuration, control field devices, valve and damper actuators, inverters, all controls wiring, including carrier systems, all power wiring and isolators from the BMS and specialists provided mechanical service power boards, setting to work, commissioning and all documentation and training necessary to allow the user to operate the installation both reliably and safely.

The BMS & specialist control systems suppliers shall provide all works necessary to provide a fully compliant installation. The BMS & specialist control systems suppliers shall refer to all contract documents and provide all necessary controls instruments, engineering and commissioning to ensure a coherent installation, whether or not they are described in this section.

2.2.2 Technical Work Scope

- Provide – includes design, supply, deliver, off load, move to work location, install, set to work test and commission, documentation and logbook.
- Supply – includes purchase, provide warranty for product, transport to site, unload, move to and fix in final location
- Design – includes the review of the specification with positive suggestions for improvement of the works, the sizing and selection of all control equipment, the sizing of all enclosures, the configuration of relay logic and plant interlocks, the generation of the functional design specifications, the writing and configuration of software routines, the sizing of control and power cables and associated carrier systems, the sizing and selection of all protective devices (such as fuses/MCBs), co-ordination of the installation with all other Contractors
- Install – includes all fixing, brackets, supports, builders work, and fire protection
- Install – includes all software, outstation configuration, integration to the head end, networks and configuration, graphics and management reports
- Set to work (automatic controls) – includes all electrical safety checks, stroking actuators, calibration of sensors, operational strategy documentation, software and testing procedures
- Set to work (electrical services) - includes all electrical safety checks, motor rotations, operational strategy and documentation and testing procedures and the provision of all IET test certificates associated with the automatic controls works
- Commission – includes commissioning plan, co-ordination and management of third party suppliers, testing the system both on and off site and demonstration to the Client
- Documentation – includes all: test certificates, testing procedures records, record drawings, operating and maintenance manuals and the health and safety file
- Logbook – as described in CIBSE TM31.

2.2.3 All controls specialist

All control specialists shall provide all works as described in the MEP specification and the following:

1. Provide functional design specification incorporating general control principles, outline panel and equipment schedules and system architecture.
2. Provide plant layout drawings identifying specific location of equipment to be installed in public areas, general location of equipment to be installed in plantrooms and wiring routes. The equipment shall be identified on the drawings with unique reference numbers.
3. Provide control panel design wiring diagrams showing protective devices, hardwired interlocking relays, control interfaces and field equipment.
4. Provide plant description of operation describing the general plant operation, the interlocking, user interfaces, alarm handling, thermal and safety control and set points.
5. Provide detailed plant and equipment schedules with specific manufacturers details, plant references and selected sizes.
6. Provide all necessary equipment controllers, system operating software and the like to provide a complete system.

7. Provide all necessary instruments and actuators for the system.
8. Provide all drive inverters for large pumps and fans. For the small pumps and fans provide integral starters, motor protection, duty rotation and auto change over control devices.
9. Provide hardwired interface to the inverters for control and a high-level BACnet/MSTP interface for monitoring.
10. Provide hardwired interface to the EC motors for control and a high-level Modbus interface for monitoring.
11. Provide all MCC/control panels necessary for the project. This shall be form 2B type 2 for standard equipment and form 3 type 3B for life safety equipment. Panels serving equipment outside the building environment shall have surge arrestors.
12. Provide all MCCs and control panels and support frames. All panels located outside the building shall be IP65 rated and complete with anti-condensation heating and weatherproof enclosure provided by the automatic control specialist.
13. Provide all actuators for ventilation dampers that require to be operated by the specialist supplied control system
14. Provide all control valves and actuators that require to be operated by the specialist control system. All control valves shall be 2 port PICV 24V modulating all actuators shall be 0-10v modulating.
15. Provide all control panels and support frames. All panels located outside the building shall be IP65 rated and complete anti-condensation heating.
16. Provide all power wiring and carrier system from the MSPB, MCC to the MEP plant and equipment. All life safety cabling shall be to BS 8519 category 3. The power wiring shall include all on load plant isolators. Inverters require early brake/late make auxiliary contacts wired in series with the enable signals.
17. Provide all controls wiring and carrier system from the MCCs/control enclosures to the MEP plant and equipment.
18. Provide all necessary control system networks, software communications, licences, graphics user interfaces and the like to form a complete system. The converged network shall be provided by a separately specified converged network specialist.
19. Provide the BMS specialist with a certified PIC statement for all interface points.
20. Provide fully configurable freely programmable DDC controller that shall communicate BACnet MSTP to terminal devices and BACnet/IP to the central plant.
21. Provide configuration, setting to work and implementation of the system software package within the DDC controller.
22. Provide a 100% witness to the BMS specialist of each field and virtual point to the BMS graphical display systems. The specialist shall confirm the measured display values units and all user interfaces at the BMS display systems and confirm these at all specialists provided connection points.

23. Provide a fully configured user display interface, this shall be suitable for both skilled and nonskilled occupants. The nonskilled occupants shall have the ability to change local set points (temperature and time of operation) within the agreed parameters. The skilled occupants shall have the ability to reconfigure operating software. The graphic display shall be colour coded and use simple text questions and answers.
24. Provide the complete control system engineering and configuration.
25. Provide all operating software, firmware and licences. Licences shall allow 100% increase of all field and virtual points at contract closure.
26. Provide fully configured web enabled DDC controllers complete with all necessary operating software to manage and supervise the MEP plant and equipment.
27. Provide fully integrated controls and plant testing, setting to work and commissioning; a detailed test and commissioning plan along with the handover plan shall be provided by the control's specialist. The Mechanical and Environmental reports shall be constructed and completed by the Building Services Contractors.
28. Provide attendance for all fire alarm and black building testing associated with the MEP plant and equipment.
29. Provide a full witness of the automatic control systems to the main contractor.
30. Provide a full witness of the automatic control systems to the client.
31. Provide a completion report of the installation, testing and demonstration of the automatic control systems.
32. Provide seven-day running (environmental testing) continuous operation of the plant and equipment to demonstrate plant stability.
33. Provide attendance at the building integrated services tests
34. Provide the automatic control system Operating and maintenance manuals.
35. Provide assistance with production of the building logbook.
36. Provide training of operators and documentation for the FM team.
37. Provide return visits to retune the system operations.
38. Provide all necessary consumables for the project.

2.2.4 Office AHU (CAM) Controls Specialist

The AHU control specialist shall provide all works as described in the MEP specification and the following:

1. Provide as described for all control specialist.
2. Provide the form 2 B type 2 power board for the AHU complete with MID approved electrical meter.
3. Provide the AHU integral DDC controller fully configured for the operation of the AHU. The controller and all ELV services shall be a separate non-door interlocked section of the AHU MCC.

4. Provide the fan tile local controller fully configured for the operation of the fan tile unit.
5. Provide all interconnecting controls network between the fan tile controller and the associated air handling plant.
6. Provide configuration and plant operation strategy for the AHU and the fan tile unit.
7. Provide all controls instruments and actuators for the fan tile units and the AHU.
8. Provide all 2 port PICV 24 Volt 0-10 Volt modulating actuators and associated control valves.
9. Provide the AHU integral control panel and power distribution board complete with MID approved electrical meter.
10. Provide the power wiring, including all local isolators, to the AHU fan motors complete with additional motor and cable protection when multiple drives are provided.
11. Provide Modbus interface for the EC fan motors and connect this to the specialist provided AHU controller and provide conversion to BACnet/IP.
12. Provide all interconnecting controls cabling between the AHU power and control panel and the peripheral equipment such as sensors and actuators and fans.
13. Provide the interconnecting controls/network cabling between the individual tenant AHUs and the tenant master AHU.
14. Provide and configure the local display unit for each AHU through which AHU operational strategy can be viewed and adjusted.
15. Provide for each tenant a master display unit through which the fan tile operational strategy and user set point can be viewed and adjusted.
16. Provide BACnet/IP high-level interface to the sitewide BMS.

2.2.5 Packaged AHU Office Fresh Air Ventilation Specialist

The AHU specialist supplier shall provide and set to work all power and control systems associated with the AHUs:

1. Provide as described for all control specialist.
2. Provide all components associated with packaged AHU and as described in the MEP specification.
3. Provide form 2B type 2 power board and associated control panel and all interconnecting wiring between the power boards, controllers and the plant and equipment (isolation dampers, fans, heat pumps, electric heaters, recuporators, thermal wheels) for the operation of the AHUs. Where air source heat pumps or electric heaters are mounted within the AHU provide the power wiring from the integral power board.
4. Provide MID approved electrical meters for power to integral air source heat pumps and separately for the electric preheaters.
5. Provide contactor, thyristor and thermal safety interlocks where electric heating is provided.
6. Provide all interconnecting networks and cabling between the AHU and the air source heat pumps

7. Provide all controls instruments and damper/valve actuators.
8. Provide the power wiring, including all local isolators, to the AHU fan motors complete with additional motor and cable protection when multiple drives are provided.
9. Provide lockstop buttons hardwired to the fan and DX system controllers for quick stop in emergency situation.
10. Provide and configure the DDC controller with all necessary operating software for the operation of the AHUs. The controller may be supplier specific but shall communicate BACnet/IP and be complete with a BACnet PIC statement.
11. Provide a colour backlit display unit associated with the AHU and a minimum viewing dimension of 200 mm. This display shall allow local interrogation of the AHU equipment status, and display and adjustment of controlling set points.
12. Provide integration to the central BMS via BACnet for general monitoring, enable and running status and supply air reset temperatures.
13. Provide the fan motors with EC drives that shall be complete with high-level interface to the AHU controller such that fan power and general status can be monitored by the central plant BMS. The AHU controller shall provide the Modbus/BACnet integration.

2.2.6 Heat Pump Specialist

The heat pump controls specialist supplier shall provide and set to work all power and control systems associated with the heat pump:

1. Provide as described for all control specialist.
2. Provide all components associated with heat pumps and as described in the MEP specification.
3. Provide the form 1 control panel complete with controllers, relay logic and all interconnecting cabling between the panel, the field sensors, the BMS interface and the air source heat pumps.
4. Provide the ASHP heating and cooling motorised isolation valves. These shall be PICV type complete with 24 Volt actuator and 0 -10 V control signal. The valve shall have end switches for proof of opening forming part of the ASHP safety circuit.
5. Provide and configure the DDC controller with all necessary operating software for the operation of the air source heat pumps and the associated primary heating and cooling circulating pumps. The controller may be supplier specific but shall communicate to the BMS BACnet/IP and be complete with a BACnet PIC statement. The heating and cooling primary pump speed control shall be via 4 to 20 mA outputs.
6. Provide a colour backlit display unit associated with the central controller with a minimum viewing dimension of 150 mm. This display shall allow local interrogation of the heat pump equipment status, and display and adjustment of controlling set points.
7. Provide integration to the central BMS via BACnet for general monitoring and flow temperature reset temperatures.
8. Provide each air source heat pump with integral control and safety interlocks.
9. Provide BACnet/MSTP connection from each air source heat pump for connection to the BMS.

2.2.7 BMS Controls Specialist

The BMS specialist shall provide all works as described in the MEP specification and the following:

1. Provide as described for all control specialists.
2. Provide all necessary instruments and actuators described in the BMS points lists.
3. Provide all fan and pump inverters. Although small fans and pumps may be provided with integral starters the BMS specialist shall include costs for the starters within the BMS works package. The exception to this are the fans within the on floor AHUs and the fresh air AHUs.
4. Provide hardwired interface to the inverters for control and a high-level interface for monitoring.
5. Provide all MCC/control panel, control instruments, valves and actuators associated with the ventilation systems, other than for the office on floor AHUs and the packaged AHUs
6. Provide office air quality sensing, CO2, VOC PM2.5 and space/RH temperature sensor for each tenant demise. This shall be connected by Modbus on a separate BMS network.
7. Provide all MCC/control panel, controls instruments actuators and valves associated with the heating systems.
8. Provide all MCC/control panel, controls instruments and valves associated with the cooling system.
9. Provide high-level and hardwired interface to the air source heat pumps.
10. Provide all interconnecting controls and network cabling installation for the air source heat pump system.
11. Provide hardwired monitoring of the air source heat pump control system for the enable and speed control of the primary heating and cooling circulating pumps.
12. Provide MCC/control panel and all controls instruments, actuators, manual reset high temperature cut out associated with the domestic hot water systems.
13. Provide enable and monitoring of the water source heat pumps associated with the HWS system.
14. Provide MCC/control panel and control instruments, actuators and inverters associated with the LTHW/domestic hot water pumping systems.
15. Provide 24V DDC device complete with integral differential pressure sensor monitoring and damper actuator for the VAV terminal units.
16. Provide the BACnet/MSTP network for the VAVs terminal units and connect these to a BMS main control panel.
17. Provide 24 Volt power wiring for the VAV devices from local BMS control panels.
18. Provide for each extract VAV unit a CO2 sensor wired to the supply box.
19. Provide all controls instruments and actuators associated for the fan coil units. The 2 port PICV 24 Volt valves and actuators, the controls transformer and all sensors shall be free issued to the FCU manufacturer for wiring off site. The FCU manufacturer shall provide fan interface card for enable and monitoring and the condensate pump.

20. Provide management of the interfaces of each disparate control system onto a common sitewide BMS platform.
21. Provide high-level interface to the office AHU (CAM) units.
22. Provide high-level network monitoring to the office AHU (CAM) EC motor Modbus connections.
23. Provide the installation of the network cabling between the office AHU (CAM) unit on the floor tiles.
24. Provide the interconnecting network between the tenant AHU (CAM) units, generally 2 per tenant.
25. Provide the heating cooling PICV 2 port valves and actuators for the AHU (CAM) unit and wire these to the AHU controller.
26. Provide high-level interface to the office fresh air AHUs.
27. Provide high-level network monitoring to the office fresh air AHU EC motor Modbus connections.
28. Provide the installation interconnecting wiring for the remote duct mounted static pressure sensors and wire these back to the AHU control panel.
29. Provide high-level interface to the basement ventilation AHU.
30. Provide controls instruments valves and actuators associated with the shower room duct mounted heating coils.
31. Provide high-level network monitoring to the basement ventilation AHU EC motor Modbus connections.
32. Provide high-level interface to the toilet ventilation AHU.
33. Provide high-level network monitoring to the toilet ventilation AHU EC motor Modbus connections.
34. Provide high-level and hardwired interface to the firefighting lobby smoke control system.
35. Provide monitoring of the accessible toilet alarm system.
36. Provide high-level interface to the back of house DX cooling systems, with full graphics of all field and virtual points associated with the DX cooling system.
37. Provide monitoring of the domestic hot water heat maintenance tape system and cold water trace heating systems.
38. Provide monitoring of the potable and nonportable tanks and associated water booster set - Integral controls and starters supplied, installed and commissioned by the mechanical contractor. The controls specialist shall carry out all interconnecting wiring between the tanks, Tanktronic, isolation valves and the pump control panel.
39. Provide controls interface to the incoming water leak detection systems.
40. Provide temperature sensing and water level sensing in the mains incoming water tanks and monitoring of the Tanktronic systems.
41. Provide monitoring of the sump pumps.
42. Provide power and monitoring for the specialist supplied rainwater harvesting system.

43. Provide power and monitoring for the specialist supplied rainwater system.
44. Provide all landlords domestic water meters, as identified on the PHE schematics and specification in compliance with regulation 4 of the water (water fittings) regulations WRAS approved complete with M-bus conductivity and connect these to the M-bus BMS/EMS energy monitoring system.
45. Provide as a temporary measure water meters for the first floor and eleventh floor tenants and connect these to a M-bus network with terminal rail within GRP enclosures for each tenant on each floor allow future connection for the tenants networked water meters. These temporary meters shall be used to validate the tenant water metering system.
46. Provide central plant heat meters (alternatively, mag flowmeters with matched temperature sensors) complete with separate outputs for flow monitoring and connect these to the sitewide BMS.
47. Provide MID approved heat meters generally these will be associated with the heating cooling services to the office and office fresh air AHUs.
48. Provide monitoring of the LV board and distribution board electrical meters and connect these to the sitewide BMS.
49. Provide monitoring of the MCC electrical meters connect these to the sitewide EMS forming part of the tenant billing and energy monitoring system.
50. Provide monitoring of the fire alarm system
51. Provide monitoring of the electrical ATS(s) using a Modbus network.
52. Provide all actuators for ventilation dampers that require to be operated by the BMS
53. Provide all control valves and actuators that require to be operated by the BMS. All control valves shall be 2 port PICV 24V modulating.
54. Provide a weather station measuring outside air temperature, outside RH, wind direction, wind speed, PM2.5, solar intensity, nitric oxide, nitrogen dioxide, Trioxygen.
55. Provide all controls wiring and network associated with the interconnections between the office air handling plants and the associated fan tile units.
56. Provide all network between the office AHUs and the master tenant AHU and provide the network connection from the master AHU to the BMS managed switches within the floor control panel.
57. Provide form 1 panels for the window control outstation, the devices shall be provided free issued by the window specialist.
58. Provide the KNX network connection from the window control outstation to the window actuators via terminal blocks mounted on the soffit of the slab within a GRP enclosure provided by the BMS specialist.
59. Provide the BMS/KNX network Gateway held within each on floor BMS outstation and connect this to the window automation controller. There is one window automation controller per floor with the exception of level 5 that has 2.

60. Provide ELV power wiring from the window specialist provided power packs to the window actuators from the GRP enclosure.
61. Provide necessary power and monitoring of the low level window magnetic microswitches. The market switches shall be wired to the GRP enclosure by the BMS specialist.
62. Provide all necessary BMS/EMS networks, software communications, licences, graphics user interfaces and the like to form a complete system. The converged network shall be provided by a separately specified converged network specialist.
63. Provide BACnet/MSTP network for the FCU.
64. Provide BACnet/MSTP network for the heat meters.
65. Provide Modbus network for the electrical meters and ATS monitoring.
66. Provide M-bus network for the domestic water system meters.
67. Provide a fully configured BMS head end supervisor operating as a thick client server suitable for unlimited simultaneous users connected via any web browser, inclusive of all operating software, email functions. The BMS specialist shall provide a 30-minute UPS for the head end workstation. The system shall be complete with HTML 5 SVG, dynamic graphics and display on demand all field and virtual points that form the project. It is likely that the converged network specialist will provide a server which the BMS specialist shall load the BMS operating system however, for tender purposes the BMS specialist shall provide the BMS head end supervisor.
68. Provide a colour backlit display unit for each tenant's space connected to the floor master control panels and utilised by the tenant to adjust the room set points and view plant status.
69. Provide the complete control system engineering and configuration.

2.2.8 DX Specialist

The DX specialist shall provide all works as described in the MEP specification and the following:

1. Provide as described for all control specialist.
2. Provide and configure the interconnecting network between the fan coil units and the external air source heat pumps.
3. Issue Provide hardwired monitoring points for the status of the air source heat pumps.
4. Provide high-level interface BACnet/IP for connection to the sitewide BMS.
5. Provide wall mounted temperature sensor/user adjustment devices within the space is served.
6. Provide backlit colour display device through which plant configuration, plant status and plant set points can be viewed and adjusted.

2.2.9 Firefighting lobby smoke control specialist

The firefighting smoke lobby control specialist BMS specialist shall provide all works as described in the MEP specification and the following:

1. Provide as described for all control specialist.
2. Provide the hardware and software associated with the firefighting smoke lobby control systems.

3. Provide all interconnecting cabling between the field instruments and actuators and the specialist provided control panels.
4. Provide all power wiring and carrier system from the MCC to the MEP plant and equipment. All life safety cabling shall be to BS 8519 category 3. The power wiring shall include all on load plant isolators. Inverters require early brake/late make auxiliary contacts wired in series with the enable signals.
5. Provide fully configured DDC controllers complete with all necessary operating software to manage and supervise the MEP plant and equipment.
6. Provide fully integrated BMS/controls and plant testing, setting to work and commissioning; a detailed test and commissioning plan along with the handover plan shall be provided by the BMS specialist. The Mechanical and Environmental reports shall be constructed and completed by the Building Services Contractors.

2.2.10 Smoke Damper Control Specialist

The firefighting smoke lobby control specialist BMS specialist shall provide all works as described in the MEP specification and the following:

1. Provide systems are described for all control specialists.
2. Provide the damper interface units and mount these along side the smoke dampers.
3. Provide the smoke damper control panel.
4. Provide transformers and positioning devices for any 3 position dampers.
5. Provide the power wring to the DIU from the local power spur.
6. Provide the interconnecting smoke damper control system networks between the control panel and the DIUs.
7. Provide hardwired signals to the BMS provided fan control panels to call for operation of the smoke extract fan that the selected speed. The fans are enabled controlled through the BMS panels via hardwired interlocking.
8. Provide hardwired interlocking between the fire alarm system in the smoke damper control panel for the determination of the zone that require smoke control.
9. Provide the software configuration of the smoke damper control system.

2.3 Standard Technical Requirements Description of Plant and Systems Operation

2.3.1 Description Of Operation

The BMS and other specialist control supplies shall be responsible for development of the description of operations, based upon the information provided in the contract specification and on the drawings. The controls specialist shall liaise with all major plant suppliers such that all requirements of theirs are included in the design. The description of operations shall include all necessary explanation for the plant operation and the construction of the software.

The normal method by which the plant is started and stopped.

- Hardwired interlocks
- Software interlocks
- Normal operations
- Operation on a sensor fault
- Operation in a power failure and restart.
- Operation on network failure.
- Operation in a fire mode
- Demands sent to other systems
- Demands received from other systems
- Initial operating set points
- Initial alarm set points
- The reaction of each plant item to a fault condition
- Head end adjustments
- Head end displayed information
- Information transmitted remotely
- Alarm messages and the response required from the operator.

2.3.2 Office on Floor Air Handling Unit

The floors, subdivided to provide services to each tenant, generally 2 per floor, shall be air-conditioned by a specialist supplied local recirculation style air handling plant complete with integral controls. This air handling plant forms part of the system that incorporates fan assisted floor tiles that have two position dampers and electric reheater. To supplement these air conditioning units mixed mode ventilation shall be provided via automatically openable windows.

The Windows shall be opened through BMS commands when the outside air temperatures at suitable conditions and which time the AHU shall be disabled.

The AHU is provided with LTHW and CHW from the roof top mounted air source heat pumps and each AHU (or pair - per tenant) shall be provided with a BMS specialist supplied MID approved heat meters that shall form part of the tenant billing system.

The AHU delivers conditioned air at variable volume to a pressurised floor void. Air is distributed to the local space via fan tile units that run at variable volume with a 2 position damper and an on-off electric heater. The supply air set point from the AHU is automatically adjusted to meet the greatest cooling demand from the fan tile units. The distribution fan in the fan tile runs at variable speed determined by calculation between the room required set point and the measured room set point.

The BMS shall monitor the outside air temperature and at suitable temperatures the high-level windows shall be, on a tenant by tenant basis, opened.

The BMS specialist shall provide MID approved heat meters for the heating and chilled connections to each office AHU and connect these via a separate energy metering network back to the BMS/EMS. The energy metering shall form part of the energy management system, shall be used during commissioning and shall form part of the tenant billing system.

Each AHU in a tenant demise shall be networked together in one unit shall be provided with a BACnet/IP connection that shall be wired to the sitewide BMS.

Each AHU shall have a separate network from the AHU to the floor tile controller.

Controls Hardware

The AHU specialist shall provide a form 2B type 2 control panel for each AHU. The door interlocked power section shall include power feeds for all fans, associated devices such as condensate pump, AHU lights and all LV services associated with the control system. The non-door interlocked control section shall contain ELV services only such as the controller and all controls terminal wiring and interlocking relays.

The power to the AHU and to the fan tile units shall be provided by the electrical specialist from the tenant distribution board. It should be noted that these have electrical meters that shall form part of the energy management and tenant billing system.

The AHU shall be provided with EC motors with the power, control and Modbus connections wired by the AHU specialist to the AHU controller. The enable, speed control and fault monitoring shall be through hardwired signals with EC motor data such as power consumed and fan speed being collated by the Modbus connection. The BMS specialist shall separately include for tender purposes a Modbus network for the CAM fan units and connect these to the BMS, if as likely this Modbus connection is not made by the AHU specialist.

The fan tiles shall be provided with AHU specialist provided individual integral controllers connected to the AHU specialist network that terminates at the AHU controller. Via the high-level network and the BMS interface the set point of the fan tiles shall be adjustable at the BMS head end and the BMS provided on floor user interface as well as locally at the fan tile controller. The fan tile controller shall modulate the damper, the fan and the electric reheater to maintain the required room air temperature. During mixed mode operation the appropriate fan tile fan shall be off, the dampers set to full recirculation and the electric heater off. These instructions (for each individual fan tile) shall be sent by the BMS to the AHU controller and then to the fan tile controller.

The AHU specialist shall provide the network connections between the fan tile control unit and the AHU controller. It should be noted that the BMS specialist shall include costs for all interconnecting cabling between the fan tile units and the AHU and network cabling between the AHUs as it is likely that the AHU specialist will be a supply/commission only contract.

The AHU specialist shall provide all controls instruments and actuators and the 2 port 24 Volt PICV modulating control valves. The AHU specialist shall provide all interconnecting cabling between the control's instruments and actuators and the AHU provided control panel. The BMS specialist shall include costs for the provision of the 2 port 24 Volt PICV modulating control valve and actuators.

Each AHU shall be controlled by the AHU supplied and configured DDC web enabled controller. The controller shall be held within a non-door interlocked section of the AHU MCC and shall be provided with a backlit colour display mounted on the fascia of the panel. The controller shall be complete with BACnet/IP output for connection to the sitewide BMS. The AHU specialist shall provide certified PIC statement for the controllers and shall demonstrate to the main contractor and to the BMS specialist field to graphic verification for every field and virtual point inclusive of AHU and fan tile units.

The AHU specialist shall provide the interconnecting network with all necessary firmware and hardware between the AHUs serving individual tenants such that there is one master AHU per tenant. At this master AHU the AHU specialist shall provide the graphical user interface that shall be used to view and manage the operating status of the AHU and the associated fan tiles.

The BMS specialist shall provide the network between the floor master AHU and the local BMS outstation that shall include a managed switch for BACnet/IP connection to the AHUs.

The BMS specialist shall provide a colour backlit user display interface for each tenant demise that should be mounted within the tenant demise and connected via an IP connection back to the local BMS control panel. The AHU operating status, for all AHUs within the tenant demise, and user adjustable parameters shall be held as an embedded graphic within the BMS floor master controller. The local user shall be able to interact with the display device to change the room temperature set point of each individual fan tile unit, operate the plant extension button and review the operating status of the AHUs within this tenant demise. The user shall also be to view current and historical data regarding energy metering associated with the individual tenant through this BMS provided user interface.

The AHU integral user display device shall generally have the same parameters as the BMS device and the AHU control system shall take the last good command from either device. The BMS device shall be the primary user interface and should be mounted on the wall within the tenant demise, the AHU interface is likely to be mounted directly on the AHU within the AHU enclosure.

The AHU specialist shall provide safety interlocks between the fire alarm system. The supply fan shall shut down through hardwired interlocking in a fire mode. The fire alarm specialist shall provide the fire alarm relay alongside each office AHU.

The AHU specialist shall provide all software interlocking that would include hardwired interlocks, AHU software HOA switch, fan software HOA switch and no existing fan alarm. If any of these are in a fault mode then the AHU shall not be able to operate. Where software switches are provided if these are in the “HAND” mode then the fan or AHU shall be able to run assuming all hardwired interlocks are healthy. The system shall revert to auto after 4 hours, this time limit is only adjustable in software configuration mode.

The plant status and plant HOA switches shall form part of a GUI displayed on an android style backlit colour display panel associated with the BMS outstation.

The EC fans require a manual speed control when operating in a manual mode. This manual speed control limited to a minimum of 20 Hz shall be available to the user through a user adjustable GUI knob displayed on the BMS head end supervisor and at the AHU control panel.

The BMS specialist shall provide 24 Volt powered MID approved heat meters for each pair of AHUs measuring the total heating and the total cooling energy. These meters shall be connected BACnet/MSTP to the sitewide EMS and powered from the BMS control panel. The meter shall display on each AHU graphic the water entering and leaving temperatures, the water flow rates and the instantaneous energy. Separate metering graphic shall be provided for the sitewide services as part of the energy management system.

The BMS specialist shall provide the tenant master controller that should be mounted generally alongside of the CAM. The controller shall be in 2 sections, a door interlocked section with ELV services and a non-door interlocked section with ELV services only, the DDC controller and for one panel on each floor the third party supplied window automation controller.

The BMS controller shall contain the embedded graphics for the office AHUs and the fan tile units serving the tenant space and shall have a layer 2 managed switch, the BACnet/IP connection to the master AHU and 24V power for the VAVs boxes and power for the wellbeing space sensors,. The controller shall also include the window KNX interface that shall be connected to the floor window automation controller. The controller shall include sufficient number of input points for monitoring the space temperature in the tenant demise and monitoring third party equipment provided for the landlord services such as the water leak detection system and the heat maintenance tape. The floor extension button shall be a GUI on the BMS display panel. The controller shall be networked by the converged network system to form part of the sitewide BMS.

The BMS specialist shall provide a space temperature sensor for each zone that shall form part of the zone optimiser such that the BMS shall enable the AHU to operate for warm up, provide low space temperature protection and operate through the occupancy period.

The window specialist shall provide the office low level window (open) monitoring sensors and wire these to the window junction box. From this junction box the individual points shall be wired to BMS outstations. If Windows are open the local fan tile shall be disabled and if more than 5 windows are open the air handling plant shall be disabled.

The BMS specialist shall provide full dynamic graphics and user interface for the AHUs and the fan tile units as if these were fully configured BMS controlled plant and equipment. The dynamic graphic shall include management of the office high-level windows and the status of all office low level windows.

The window specialist shall provide all KNX interface detail allowing the BMS specialist to write to the individual window actuators.

The AHU specialist shall provide all operating software configuration and be in attendance throughout BMS witnessing, 7 day environmental testing and any Building IST.

Office AHU setting to work testing and commissioning

The on floor AHU specialist shall provide full technical details including software, wiring diagrams, off site software and panel testing of the AHU, the controllers and the fan tiles. These shall be provided prior to delivery.

The AHU specialist supplier shall set to work test and commission the complete system of their supply. The commissioning shall include full integration with the sitewide BMS and the AHU specialist shall confirm, test and demonstrate to both the BMS specialist and later to the client full point to graphic (100% of all field and virtual points) between the AHU system including the fan tiles and the BMS head end dynamic graphics.

The AHU specialist shall provide full attendance during the 7 day environmental testing and shall provide the handover system reports that demonstrate that the AHU has performed as expected during this environmental test. These handover reports shall include all plant installation manuals, operating and maintenance manuals, hardware and soft copy of all software, panel wiring diagrams, system set points, system alarm set points.

The AHU specialist shall provide 3 return visits at 3 month intervals following practical completion where they shall re-demonstrate the operation of the AHU and fan tile system during winter, spring/autumn and summer modes. During this testing, the AHU specialist shall re-confirm all field to graphic points, all user

interfaces and all system management functions. These visits are technical soft landing types and are not to be seen as time spent correcting construction snags and defects.

System Operation

The offices shall be air conditioned by the down flow AHUs that are enabled to suit the local system optimiser with fresh air provided from the office air handling plant.

Each tenant shall have a separate optimiser held within the BMS floor master controller enables the tenant AHUs for optimised warm up and cool down, occupancy and low space temperature protection.

A building wide purge routine shall be provided that when active runs the tenants AHUs at full speed with a nominal return air set point of (21)ºC and dead bands of (±5)ºC This routine is selectable from the BMS head end supervisor and runs for (4) hours and then reverts to normal automatic control. During this mode the office AHUs also operate with a supply air set point of (21) ºC and dead bands of (±5) ºC. The AHU cooling valves shall remain closed during this strategy.

The optimiser shall enable the tenant AHUs for warm up to achieve space temperature set point of (20)ºC, at occupancy time with a maximum of 2 hour search time. During this period the fan tile units shall run at full speed with the heating modulated to maintain the return air set point of (35)ºC If any fan tile achieves its nominal space set point (22)ºC then normal operation shall commence. The warmup period shall have a maximum of (2)hours search time and under no circumstances shall the cooling valves on the AHU operate until occupancy time.

The optimiser shall enable the tenant AHUs for low space temperature protection operating the AHU as for warm up if the space temperature is <(14 ± 2)ºC

During occupancy the fan tile unit shall operate to its local temperature set point modulating the fan speed as necessary and opening or closing the floor damper and enabling/disabling the electric heater to maintain the nominal local room temperature set point.

The AHU shall operate at variable fan speed dependent upon the air being drawn by the floor tiles. The AHU supply air temperature shall be reset between limits to meet the greatest cooling demand from any floor tile. The supply air set point at start-up shall be (18)ºC and modulate up and down as appropriate.

Each fan tile unit shall have a nominal set point and adjustable offset set point all of which can be manipulated through the BMS head end supervisor, the BMS tenant display unit, at the master AHU and at the fan tile controller, the set point shall take the last command.

To accommodate excessive high or low external temperatures the BMS shall automatically raise or lower the fan tile nominal set point.

Each AHU shall be provided with the software auto/off/on switch that is adjustable from the BMS head end supervisor. If ON is selected then the AHU shall operate normally for a maximum of (4) hours and return to auto. If off is selected then the AHU will not operate however valve exercise and water quality routines remain active.

Each fan tile unit shall be provided with the software auto/off switch that is adjustable from the BMS head end supervisor. If auto is selected then the fan tile shall operate normally. If off is selected then the fan tile will not operate.

The BMS specialist shall provide window (open) monitoring sensors and wire these to the BMS. If Windows or open the local fan tile shall be disabled and if more than 5 windows are open the air handling plant shall be disabled.

Operation

When required to operate in normal mode all AHUs in the tenant demise shall operate in the same manner as described below.

The AHU shall be enabled, by the sitewide BMS whenever a served tenancy is in the occupancy mode, or if the served tenant plant extension is active, or if the individual AHU BMS software HOA switch is in the hand position or if a building purge is required and for warm up and low space temperature protection. The AHU shall run until the end of occupancy, the end of the purge period or for (4) hours when in the hand mode when it shall return to auto.

When the AHU is required to run the fan shall be enabled assuming all interlocks are healthy.

The AHU shall be disabled if more than 5 of the lower windows in the served area are open. The fan tile adjacent to an open window shall be disabled all through BMS commands.

The high-level window shall be opened automatically by the BMS when the outside air temperature is at a suitable level and the AHU shall be shut down.

Hardwired Interlocks

The supply fan hardwired interlocks include: fire alarm healthy. The software interlock (with suitable time delays) shall include hardwired interlocks, no existing fan alarm, the AHU software switch in either hand or auto, the supply fan software switch in hand or auto.

Motor Fault

The AHU control system shall monitor the fan status both via a fan differential pressure switch and individually via the Modbus connection to each fan.

If the fan has been called to run and the differential pressure switch has not made after a suitable grace time then the AHU shall shut down and an alarm raised.

If a fault is detected from an individual fan via the high level interface or by the hardwired fault connection then the AHU shall be shut down an alarm raised.

Plant Off State

When the AHU is off the LTHW and CHW valves are closed, and the AHU and fan tiles shall be off.

Valve exercise and water flush routine

The AHU heating and cooling valves shall be opened and closed fully in one cycle, once per day at 03.00. The BMS shall send a command to the AHU controller to open the heating valve for (1) hour and then open the cooling valve for (1) hour during which time the BMS shall enable the secondary heating and chilled water circulating pumps to provide valve exercise and water quality circulation routine.

Optimum warm up operation

The BMS shall enable all AHUs in an individual tenant space to start to suit the optimiser parameters and to achieve a nominal 20°C at start time. The optimiser shall have a maximum search time of (2) hours.

When the AHU is operating in this mode the supply air set point shall be elevated to a nominal 30°C, the supply fan shall run under normal control.

Irrespective of any feedback from fan tile units the system shall continue to operate with this 30° set point until the start of occupancy when normal control shall be initiated.

Low space temperature protection

The BMS shall enable all AHUs in an individual tenant space to start to if the local space temperature is (14 ± 2)ºC

When the AHU is operating in this mode the supply air set point shall be increased to a nominal 30°C, the supply fan shall run under normal control.

Irrespective of any feedback from fan tile units the system shall continue to operate with this 30° set point until the space temperature rises above required set point.

System Thermal Control

When the AHU is running in normal occupancy the supply air set point shall be achieved by modulation of the heating and cooling valves with a PI loop.

The supply air set point shall be determined by the AHU controller to be the highest temperature that can be utilised to provide cooling to any floor tile that is in a cooling demand.

The supply air set point shall have two user selectable units, a toggle switch shall be provided on the BMS supervisor and at the AHU display panel to select either control strategy. This shall be either a constant temperature that is adjustable at the head end and the AHU display screen between limits (16 to 25)ºC OR a variable temperature that is dependent on the fan tile cooling demand (15 to 22)ºC At start-up the AHU shall provide air at a nominal 22°C decrease if any space is in a cooling demand. When all spaces are in a heating demand the decrease shall cease and the supply air temperature elevated at (0.5)ºC/30 minutes until any space reverts to cooling.

The supply air set point shall have a dead band of ± 1ºC in which the heating and cooling valves remain closed.

AHU Maintenance Strategy

The AHU specialist shall provide and configure software for an AHU maintenance strategy program. When this maintenance strategy is active the AHU shall be enabled, and the supply air set point shall be set to (30)ºC. The system shall run for (30) minutes and then return to auto for (5) minutes. The supply air set point shall be set to (15)ºC and shall run for a further (30) minutes and then return to auto for (5) minutes and then revert to off. An automatic report shall be generated that describes the operation of the AHU in this test routine.

The maintenance fail alarm shall be active if during the cooling mode the supply air temperature has not fallen below (16)ºC or in the heating mode risen above (25)ºC

To enable full airflow the fan tile units shall operate to maintain a room temperature of 15ºC

The test routine shall include a report on the values received from the CO2 sensors and where these are more than (10)% different from each other a maintenance alarm shall be raised.

The routine is initiated manually by the FM team at the BMS supervisor.

Building Ventilation Purge

If the building/tenant ventilation purge is active then the AHU and fan tiles operate at full speed with a normal return temperature set point of (21)ºC and dead bands of (±5)ºC During this mode the AHU heating and cooling valves shall be closed.

Fan Speed Control

The supply fan shall run at variable speed.

Fan tile control

The fan tile control system shall be enabled whenever the AHU is required to operate. When operating in warm up mode the fan tile shall have a forced set point of 15°C return air.

When operating in low space temperature protection mode the fan tile shall have a forced set point of 15°C return air. These lower air temperature setpoints are necessary to ensure that the damper is fully open and that the electric heaters are not enabled.

The room air set point that is adjustable between limits is achieved by modulation of the fan speed in conjunction with cool air from the AHU for heating and full recirculation and heater enabled when in a heating mode.

Each fan tile unit shall have a nominal set point and adjustable offset set point all of which can be manipulated through the BMS head end supervisor, the BMS tenant display unit, at the master AHU and at the fan tile controller, the set point shall take the last command. The nominal set point (21)ºC can be adjusted by a level 3 user by (±3)ºC this value when adjusted remains fixed. The adjustable offset set point can be altered by any user by (±3)ºC from the devices previously mentioned. This offset however reverts to 0 at 02.00 every day.

To accommodate excessive external temperatures the BMS shall automatically reset the fan tile nominal set point such that for each 1ºC. that the outside air temperature is above 25oC.(adjustable at the head end supervisor 25°C to 35°C) the nominal set point shall be increased by 1°C For each 1ºC. that the outside air temperature is below 5ºC (adjustable at the head end supervisor 5ºC down to -10ºC) the nominal set point shall be reduced by 1°C The adjustment limit shall however not allow the return/room air set point to rise above 26ºC or fall below 19ºC. When this auto reset is active, Indication shall be provided on the BMS head end supervisor and the floor graphic displays

Fire Mode

In a fire mode the AHU shall shut down through hardwired interlocks and the fan tile units through software. The valves shall however continue to operate for stage 1 frost protection, valve exercise and water quality routines.

Sensor Faults

The control sensors shall be monitored and if out of range, then alternative sensors shall be utilised for the control strategy.

- If the return air temperature is out of range, then the AHU thermal control shall be from the supply air temperature sensor with a set point of (18)ºC
- If the supply air temperature is out of range, then the AHU thermal control shall be from the return air temperature sensor with a set point of (21)ºC
- If the supply air static pressure sensor is out of range, then the supply and extract fans shall run at a nominal (30)Hz.

System Alarms

The BMS shall monitor the office ventilation system for status and raise alarms on system mismatch with a suitable grace time.

The critical alarms, that shall be indicated on the AHU graphic and in the alarm list, illuminate the AHU fault lamp and be issued as an email shall be:

- Supply fan failing to run when commanded on.
- Any window open after 18.00 and before 08.00.

All critical alarms shall auto reset at midnight, shall reset if the alarm reset button on the graphic is operated and shall reset if the alarm reset button is operated on the BMS controller.

The maintenance alarms, that shall be indicated on the AHU graphic and held in the alarm list shall be:

- Filter dirty.
- Supply air temperature ± 5ºC from set point.
- Return air temperature ± 5ºC from set point.
- Fan tile fault.
- Room temperature ± 5ºC from set point.
- Control Valve manually overridden.
- Fan speed manually overridden.
- Sensor out of range.
- EC motor – overheat
- EC motor – general error

All maintenance alarms shall be cleared when the state returns to normal.

Trend Logs

The BMS specialist shall set the following trends to be logged:

- Fan change of state - running/not running
- Supply fan speed
- Outside air temperature.

- Return air set point
- Return air measured temperature
- Supply air set point
- Supply air measured temperature
- Cooling & Heating valve positions (AHU/BMS output)
- AHU LTHW entering water temperature
- AHU LTHW leaving water temperature
- AHU LTHW flow rate (common for 2 units)
- AHU CHW entry water temperature
- AHU CHW leaving water temperature
- AHU CHW flow rate (common for 2 units)
- Accumulative heat energy (common for 2 units)
- Instantaneous heat energy (common for 2 units)
- Accumulative cooling energy (common for 2 units)
- instantaneous cooling energy (common for 2 units)
- Return air CO2 for each tenant
- Individual fan speed – HLI from fan
- Individual fan power – HLI from fan.
- Fan tile return air set point.
- Fan tile measure return air temperature.

These values shall be set for (15) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

Heating/Cooling Demands

The BMS shall monitor the AHU unit valve positions and enable the duty heating or cooling circulating pump whenever (2) AHUs in any demise are >(15)% open or if (1) valve is >(80)% open. The (80)% values shall be user adjustable, by a level 3 user, between (80 to 15)%. The demand shall remain active until all AHU valves are closed for >(5) minutes.

Central plant demands

Whenever a tenant's AHU is required to operate in the occupied time mode (not warm up or low space temperature protection) the appropriate fresh air AHU shall be enabled as will all office toilet ventilation systems.

The central hearting and cooling plants will be enabled automatically dependent on the ventilation plant heating/cooling valves positions.

Floor Plant Extension Button

Generally, the units in the tenant demise operate to the plant optimiser however tenant floor plant extension buttons as a software switch indicated on the floor graphic shall be provided. When this button has been operated the AHUs in the tenant demise shall run under normal control for (4) hours and then revert to auto control. The appropriate office fresh air ventilation plant and the general building toilet extract systems shall be enabled at this time.

Global Commands

The BMS specialist shall configure global commands at the head end supervisor for use both during commissioning and the maintenance team.

The global commands that shall be applied on a tenant by tenant basis include:

- Set all AHU units and associated fan tile units to auto/off/on operation.
- Reset all fan tile nominal temperature set point between the value of (18 to 25)ºC
- Reset all offsets set points to 0.
- Set the cooling valve to fully open, fully closed or auto control
- Set the heating valve to fully open, fully closed or auto control.
- Set the optimiser parameters – start/stop time, warm up temperature to be achieved, low space temperature set point

The global commands that shall be applied on a site wide basis include:

- Set all AHU units and fan tile units to auto/off/on operation
- Reset all nominal temperature set point between the value of (18 to 25)ºC
- Reset all offsets set points to 0.
- Set the optimiser parameters – start/stop, warm up temperature to be achieved, low space protection set point.
- Set the cooling valve to fully open, closed or auto control.
- Set the heating valve to fully open, closed or auto control.

The last given global command takes precedence.

Whenever plant is set to ‘ON’ it shall run in that state for (4) hours and then revert to auto control.

Graphic Display

At the BMS head end supervisor and the office tenant floor master control panel the status of each fan tile and the AHU unit shall be available via the dynamic graphic However, this information shall also be provided in tabular form such that the status of individual fan tiles can be seen at the same time on a floor by floor basis.

The graphic shall be held within the BMS server and automatically downloaded on changes to the BMS floor control panel. The BMS tenants display shall web brows to this embedded local graphic rather than the server. This will allow user interface if the converged network is inactive.

All operating set points shall be held at the local BMS controller with adjustments through the supervisors or locally at the controller.

Fan tile unit	Status	Fan speed	Nominal Set point	Offset adjustment	Actual set controlling	Return/space temperature	Heating out put	Cooling valve output	Damper position
Reference number	On/off	%	°C	± °C	°C	°C	%	%	%
Reference number	On/off	%	°C	± °C	°C	°C	%	%	%

The dynamic graphic shall be a floor plan that shall display on the first overview the return air /space temperature measured and the reference of the fan tile unit.

Drilling down from this overview the individual status of each fan tile shall be displayed as a dynamic graphic. On this graphic it shall be possible to, adjust the return/space temperature set point and manually control all of the analogue and digital outputs.

The AHU shall be displayed as a dynamic graphic with all field and virtual points addressable from the supervisor, the multiple floor controller display panel and the tenants display device as if this were a BMS wholly controlled device. The graphic shall be held in the sever and automatically uploaded to the BMS multiple floor controller. The tenant display device shall web brows to this graphic rather than the server. This will allow user interface if the converged network is inactive.

As a minimum the following shall be available from the AHU & fan tiles to the BMS:

AHU read	AHU write
AHU/Fan running	AHU/Fan enable - the BMS shall set the system to auto, off or on.
Fan failed to run	
Fan speed	
Fan running current	
Fan kw	
Chilled water valve position	Set CHW valve to automatic control or manual to achieve any fixed position
LTHW valve position	Set LTHW valve to automatic control or manual to achieve any fixed set position
Supply air set point	
Supply air temperature	

AHU read	AHU write
Return air temperature	
Filter dirty	

Fan tile read	Fan tile write
Fan running	Fan enable - the BMS shall set the fan to auto, off or on.
Fan failed to run	
Fan speed	
Damper position	set damper to auto or closed or open position.
Room air set point	room air set point
Room air temperature	
Plenum air temperature	
Heater battery % operation	Set heater to auto/off operation.
Heater battery fault	

Fresh air supply

The fresh air to the on floor air handling plant shall be provided via a variable air volume terminal unit and a matched VAV extract. The extract units shall be fitted with a return CO2 sensor wired to the supply VAV device. The supply controller shall contain software to modulate the supply and exhaust units to maintain an upper level of (800) ppm. Where values are lower than this the unit shall operate at minimum volume.

2.3.3 Mixed Mode Ventilation - Windows

The office floor is provided with automatically openable windows controlled and managed by the sitewide BMS, these windows are mounted at high-level in the office space. Beneath these windows are manual openable windows that can be operated by the local occupant, these lower windows shall be provided with microswitches wired by the BMS specialist such that the open (or non-closed) position of these windows can be monitored.

Additionally, there are external awnings that shall be controlled automatically by the sitewide BMS with the position being able to be overridden through the BMS head end supervisor.

Controls hardware

The windows specialist shall provide intelligent actuators, power packs and window automation controller for the operation of the high-level windows. The specialist contractor shall provide closed position microswitches for the low-level windows on all levels.

The BMS specialist shall mount the window automation controller and necessary powerpack within one of the on floor BMS control panels – nominally this shall be the control enclosure in the tenant 1 area CE-X-01, although an level 5 there is a requirement for 2 window automation controllers each controller can only control 30 windows.

The window specialist shall provide control cables, network and power cabling from the window actuators and the microswitches with sufficient cable length that can be terminated by others in the local junction box.

The BMS specialist shall provide junction boxes that shall be mounted on the slab soffit complete with terminal rails for the KNX network from the automation controller, the KNX connection to the intelligent actuators, power from the powerpack to the actuators and monitoring status for the lower windows. Each junction box shall control up to 3 windows.

The electrical specialist shall install the power packs and provide all upstream isolation, on the LV carrier system. The BMS specialist shall wire power from the power packs to the actuators via the junction box.

The BMS specialist shall provide the interconnecting KNX network around the floors from the floor automation controller as a bus to each junction box. Although there is more than one tenant per floor generally there is only one network with the exception of level 5 that requires two, as the automation controller can only manage a maximum of 30 actuators.

The BMS specialist shall include for connection of all cables from the window actuators and the monitoring system to the junction box and all interconnecting cabling between the junction boxes, the local power feed and the KNX network.

The BMS specialist shall work in conjunction with the window automation specialist to develop the interface gateway.

The window specialist shall ensure that all window actuators are complete with integral safety interlock to prevent overdrive.

The lower windows that are manually operated shall be provided with microswitches by the cladding specialist to indicate the not closed status. The cladding specialist shall wire the microswitch to the same junction box as the automatic window operators are wired to. The BMS shall monitor the status of the individual windows and raise alarms when these are open out of occupancy. When the windows are deemed not to be closed the BMS shall send instructions to the AHU controller such that the local fan tile fan is turned off, the damper set to full recirculation and the heater held off.

Operation

The high-level office windows shall be opened on a tenancy by tenancy basis. Generally, there shall be a single BMS software switch for each zone such that all the windows can be set for auto/open/closed operation. Separately each window shall have an auto/off BMS software switch such that specific windows can always be held shut irrespective of any other demands.

The high-level windows shall be opened during the occupancy period if the outside air temperature is between limits (16 to 25)ºC these limits shall be adjustable at the BMS head end supervisor. When these windows are opened the BMS shall via the high-level network send instructions to the AHU controller to disable the air handling plant.

During out of hours occupancy and if the out of hours occupancy BMS software hand off auto switch is set to auto the BMS shall open the appropriate tenant office windows if the inside air temperature is >(24)ºC. and the outside air temperature between (16 to 25)ºC.

The window shall be closed if it is raining or if the outside wind speed is > TBA.

2.3.4 Solar Shading

The cladding specialist shall provide external solar shading complete with all actuators and wire these to a junction box provided by the BMS specialist located within the office attached to the slab soffit. The actuators shall be 24 Volt AC and operate via 0 to 10 Volt DC signals that will be derived from the BMS outstations. The actuators shall be complete with end stop clutches and positional feedback.

The BMS specialist shall provide interconnecting wiring from the junction box to the BMS controlling outstation.

The BMS specialist shall provide a solar shading package that shall include a mathematical map of the building construction and external solar sensors. The appropriate awnings shall be extended if the facade is in sunlight and the solar intensity is above set point.

2.3.5 Air Quality

To provide air quality measurements that are generally in line with the Well standards the BMS specialist shall provide separate air and room quality monitoring via a Modbus device wired to and powered from the BMS controller. The device of which there shall be 2 per tenant should include: temperature, RH, CO2, PM 2.5, TVOC The device shall be similar to a Kaiterra SenseEdge Mini.

2.3.6 Office Air Handling Plants

The offices are provided with fresh air from a variable volume variable temperature packaged air handling plants. The systems are enabled to suit the office occupancy and the heat recovery, heating cooling systems are modulated in sequence to maintain the required supply air temperature. The controller shall be provided with a BACnet/IP connection that shall be connected to the sitewide BMS.

Fresh air is provided to the office floors via locally control variable air volume terminal units that modulate to maintain a nominal 800 ppm of CO2.

Construction remit

The offices are ventilated by two packaged air handling plants located in the basement. These ventilation systems comprise variable volume supply and extract fans, heat recovery systems, DX heating/cooling coils with integrally mounted air source heat pumps and where necessary electric reheaters.

The power to the AHU panel shall be from the Electrical specialist supplied switchboard. The power to the electric heater, the fans, the ASHP and the heat recovery equipment shall be from the AHU packaged panel provided by the AHU specialist.

The AHU specialist supplier shall provide door interlocked form 2B type 2 control panel for the power section and a non-door interlocked form 1 panel for the control section. All LV services associated with

the control section shall be housed within the power section, only ELV services shall be present in the control section. The outgoing ways to the electric heater and the air source heat pumps shall be provided with MID approved electrical meters with Modbus output, these shall be wired to a separate ELV section of the control panel.

The AHU specialist shall provide a contactor hardwired interlocked with the high temperature cut out and thyristor for the electric reheater and mount these in the power section of the control panel.

The AHU specialist shall provide a refrigerant leak detection system within the AHU supply and extract systems.

The AHU specialist shall provide a back lit colour display system complete with touchscreen on the fascia of the AHU control panel. The screen shall provide dynamic graphic and text pages showing the plant status and allowing local manual integration and adjustment and have a minimum viewing dimension of 200 mm.

The AHU specialist shall provide power wiring to the fans, electric heater, ASHP and the heat recovery systems from the power section of the control panel. Where multiple fans are provided each fan shall have individual electrical protection for the motor and the power feed.

Isolators shall be provided for each fan section, the heat recovery section, the ASHP and the electric heater. Associated with this shall be lockstop buttons that shall shut power down to the complete AHU in the event of emergency. These lockstop buttons to be mounted alongside the AHU, local to the supply fan, local to the extract fan, and wired back by the AHU specialist to a contactor mounted in the power section of the mechanical services power board serving the AHU. This contactor shall have a 3 wire operated circuit with a reset button mounted on the AHU control panel acting as the start and the lockstop button acting as the stop. The 3 wire latching relay system shall be held within the AHU panel.

The AHU specialist shall provide and install all controls instruments and actuators and wire these to the DDC control panel mounted in the control section.

The AHU specialist shall free issue ductwork static pressure sensors for the supply and extract systems which shall be installed wired by the BMS specialist.

The AHU specialist shall provide all interconnecting controls and network wiring inclusive of carrier systems between the AHU control panel and the air source heat pumps.

The AHU specialist shall provide and configure all necessary software, hardware and safety interlocking relay logic for the operation of the AHU. The controller shall be provided with BACnet/IP communications for connection to the sitewide BMS through which full read and write facilities shall be available.

The AHU specialist shall provide all hardwired safety interlocking that would include: supply and extract fans hardwired interlocked with damper proven open status, high pressure healthy, low pressure healthy, refrigeration leak detection system healthy, DX system hardwired interlocked with supply and extract fan flow proving status, electric reheat hardwired interlocked with supply fan flow proving status and high temperature cut out.

The AHU specialist shall provide all software interlocks that shall include: hardwired interlocks, AHU software HOA switch in hand or auto, no existing fan alarm.

A separate hardwired interlock shall be provided in the AHU control panel for connection to the sitewide fire alarm system.

The EC motors shall be provided with Modbus output that shall be connected to the AHU manufacturers provided controller and converted to BACnet to allow the BMS to read the fan status and in particular the running speed and the instantaneous power. The BMS specialist shall include for tender purposes separate network to these EC motors connected directly to the BMS.

The EC motors shall be controlled by 0-10V hardwired signals from the AHU controller with hardwired fault and running status monitored.

The AHU specialist shall provide and configure all necessary software for the operation of the AHU and shall include setting to work testing and commissioning. Return visits shall be required during the future heating and cooling seasons.

Fresh Air AHU Setting to Work Testing and Commissioning

The primary AHU specialist shall provide full technical details including software, wiring diagrams, off site software and panel testing of the AHU, these shall be provided prior to delivery.

The AHU specialist supplier shall set to work test and commission the complete system of their supply. The commissioning shall include full integration with the sitewide BMS and the AHU specialist shall confirm, test and demonstrate to both the BMS specialist and later to the client full point to graphic (100% of all field and virtual points) between the AHU system and the BMS head end dynamic graphics.

The AHU specialist shall provide full attendance during the 7 day environmental testing and shall provide the handover system reports that demonstrate that the AHU has performed as expected during this environmental test. These handover reports shall include all plant installation manuals, operating and maintenance manuals, hardware and soft copy of all software, panel wiring diagrams, system set points, system alarm set points.

The AHU specialist shall provide 3 return visits at 3 month intervals following practical completion where they shall re-demonstrate the operation of the AHU during winter, spring/autumn and summer modes. During this testing, the AHU specialist shall re-confirm all field to graphic points, all user interfaces and all system management functions. These visits are technical soft landing types and are not to be seen as time spent correcting construction snags and defects.

Operation

The BMS shall enable the ventilation plant to operate based on the demand from the office floor or if the site wide purge is active. The AHU shall also run for (4) hours if the AHU BMS software hand/off/auto switch is set to hand.

A building wide purge routine shall be provided that when active runs all office AHUs (CAM) units with a nominal return air set point of (21)ºC and dead bands of (±5)ºC. This routine is selectable from the BMS head end supervisor and runs for (4) hours and then reverts to normal automatic control. During this mode, the office AHUs also operate with a supply air set point of (21)ºC and dead bands of (±5)ºC.

The AHU specialist software shall enable the AHU when instructed by the BMS and assuming all interlocks are healthy. The BMS software interlock shall include fire healthy.

The AHU shall provide air at variable temperature dependent on the outside air temperature. The BMS shall calculate the supply air set point and send this to the AHU controller which in turn shall modulate the system as required.

If the outside air temperature is <(10)ºC then the supply air set point shall be (22)ºC and if the outside air temperature is >(17)ºC the supply air set point shall be (17)ºC. between these outside air temperatures, a linear progression of the supply air set point shall be provided.

The AHU controller shall modulate in sequence the heat recovery, heating/cooling DX system and electric reheater to maintain the supply air set point. During any defrost cycle the AHU the software shall ensure that the supply air temperature is never <(15)ºC.

When the system is shut down the DX unit and electric heater shall be disabled and the fans run on for a further (5) minutes.

The supply and extract fans shall run at variable speed to maintain the required system static pressure.

The supply and extract fan shall be software interlocked such that the failure of one of the other shall stop the system operating. Where fan walls are provided a failure of any fan (unless this is provided with a mechanical nonreturn damper) shall shut the complete AHU down.

If the AHU is running and the refrigeration leak detection system is in alarm, the supply fan shall be disabled and the extract fan ran for a further 5 minutes and then shuts down.

Sensor fault

If the supply air temperature set point received at the AHU controller is out limits, then the AHU shall revert to a constant supply air temperature of (17)ºC.

If the supply air temperature fails then the unit shall operate to a constant return air temperature of (20)ºC.

Global commands

The BMS specialist shall configure global commands at the head end supervisor for use both during commissioning and by the maintenance team. The global commands that shall be applied on a site wide basis include:

- set all AHU units to auto/off/on operation
- send a fixed outside air temperature between values of 10ºC and 17ºC

Whenever plant is set to ‘ON’ it shall run in that state for (4) hours and then revert to auto control.

Graphic display

At the BMS head end supervisor the status of each AHU shall be available via the dynamic graphic. All field and virtual points shall be displayed and all shall be adjustable between limits.

The operating status of the EC fans shall be available either as a dialogue box or on the AHU user page.

The graphics shall display totally run time for each AHU. A level 3 user shall be able to reset this value back to 0.

System alarms

The BMS shall monitor the AHU for status and raise alarms on system mismatch. The alarm is raised shall be:

- AHU failing to run when commanded on.
- AHU running when not commanded on by BMS.
- Individual fan fault.
- ASHP fault.
- Dirty filter
- Heat recover unit fault
- Electric heater high temperature trip.
- Supply air temperature ±(3)ºC from set point.
- Any part of the AHU strategy operating in manual override. - This shall change the colour of the AHU controlled devices on the general graphic display.

Trend logs

The BMS specialist shall set the following trends to be logged:

- Fan change of state - running/not running.
- Supply air temperature
- Supply air set point.
- DX Cooling % output
- DX heating % out put
- Electric heater % output
- Electric heater off coil temperature.
- Outside air temperature.

These values shall be set for (10) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

VAV units

The VAV units shall be provided with BMS DDC controllers complete with on-board differential pressure sensing and integral modulating damper actuator.

The units shall be powered from a local BMS panel with communications via BACnet/MSTP back to the BMS outstations.

Each tenant shall have a supply and extract terminal unit with a duct mounted CO2 sensor in the extract system. This shall be wired to the supply VAV controller that shall contain software logic to reset the supply and extract air flow rates to maintain an upper limit of 800 ppm of CO2. At any value below this the VAV unit runs at the minimum set point. If the measured value rises above set point, then the VAV unit is modulated towards the maximum flowrate. These air flow rates should be determined during commissioning but for Initial purposes may be considered as follows:

If the floor is out of occupancy the VAVs unit shall be set to the minimum value.

Sensor out of range

If the CO2 sensor is out of range, an alarm shall be raised and the VAV unit shall be set to operate the maximum design air volume.

System alarms

The BMS shall monitor the VAV and CO2 for status and raise alarms on system mismatch. The alarms raised shall be:

- CO2 >1200ppm.
- Any part of the VAV strategy operating in manual override. -

Trend logs

The BMS specialist shall set the following trends to be logged:

- Supply air volume.
- Extract air volume.
- CO2 level.

These values shall be set for (10) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

2.3.7 Toilet AHU

The office toilets are ventilated by constant volume variable temperature packaged air handling plant mounted on the roof. The system is enabled whenever any office AHU is running in occupancy or if the toilet time clock is active. The AHU controller shall be provided with a BACnet/IP connection that shall be connected to the sitewide BMS.

Construction remit

The office toilets are ventilated by a packaged air handling plant located on the roof. The ventilation system comprises constant volume supply and extract fans, heat recovery systems, DX heating/cooling coils with integrally mounted air source heat pumps and where necessary electric reheaters.

The power to the AHU panel shall be from the BMS provided MSPB. The power to the electric heater, the fans, the ASHP and the heat recovery equipment shall be from the AHU packaged panel provided by the AHU specialist.

The AHU specialist supplier shall provide door interlocked form 2B type 2 control panel for the power section and a non-door interlocked form 1 panel for the control section. All LV services associated with the control section shall be housed within the power section, only ELV services shall be present in the control section. The outgoing ways to the electric heater and the air source heat pumps shall be provided with MID approved electrical meters with Modbus output, these shall be wired to a separate ELV section of the control panel.

The AHU specialist shall provide a contactor hardwired interlocked with the high temperature cut out and thyristor for the electric reheater and mount these in the power section of the control panel.

The AHU specialist shall provide a refrigerant leak detection system within the AHU supply and extract systems.

The AHU specialist shall provide a back lit colour display system complete with touchscreen on the fascia of the AHU control panel. The screen shall provide dynamic graphic and text pages showing the plant status and allowing local manual integration and adjustment and have a minimum viewing dimension of 200 mm.

The AHU specialist shall provide power wiring to the fans, electric heater, ASHP and the heat recovery systems from the power section of the control panel. Where multiple fans are provided each fan shall have individual electrical protection for the motor and the power feed.

Isolators shall be provided for each fan section, the heat recovery section, the ASHP and the electric heater. Associated with this shall be lockstop buttons that shall shut power down to the complete AHU in the event of emergency. These lockstop buttons to be mounted alongside the AHU, local to the supply fan, local to the extract fan, and wired back by the AHU specialist to a contactor mounted in the power section of the mechanical services power board serving the AHU. This contactor shall have a 3 wire operated circuit with a reset button mounted on the AHU control panel acting as the start and the lockstop button acting as the stop. The 3 wire latching relay system shall be held within the AHU panel.

The AHU specialist shall provide and install all controls instruments and actuators and wire these to the DDC control panel mounted in the control section.

The AHU specialist shall provide all interconnecting controls and network wiring inclusive of carrier systems between the AHU control panel and the air source heat pumps.

The AHU specialist shall provide and configure all necessary software, hardware and safety interlocking relay logic for the operation of the AHU. The controller shall be provided with BACnet/IP communications for connection to the sitewide BMS through which full read and write facilities shall be available.

The AHU specialist shall provide all hardwired safety interlocking that would include: supply and extract fans hardwired interlocked with damper proven open status, high pressure healthy, low pressure healthy, refrigeration leak detection system healthy, DX system hardwired interlocked with supply and extract fan flow proving status, electric reheat hardwired interlocked with supply fan flow proving status and high temperature cut out.

The AHU specialist shall provide all software interlocks that shall include: hardwired interlocks, AHU software HOA switch in hand or auto, no existing fan alarm.

A separate hardwired interlock shall be provided in the AHU control panel for connection to the sitewide fire alarm system.

The EC motors shall be provided with Modbus output that shall be connected to the AHU manufacturers provided controller and converted to BACnet to allow the BMS to read the fan status and in particular the running speed and the instantaneous power. The BMS specialist shall tender purposes include costing a separate Modbus network to the fan speed drives.

The EC motors shall be controlled by 0-10V hardwired signals from the AHU controller with hardwired fault and running status monitored.

The AHU specialist shall provide and configure all necessary software for the operation of the AHU and shall include setting to work testing and commissioning. Return visits shall be required during the future heating and cooling seasons.

Toilet AHU Setting to Work Testing and Commissioning

The AHU specialist shall provide full technical details including software, wiring diagrams, off site software and panel testing of the AHU, these shall be provided prior to delivery.

The AHU specialist supplier shall set to work test and commission the complete system of their supply. The commissioning shall include full integration with the sitewide BMS and the AHU specialist shall confirm, test and demonstrate to both the BMS specialist and later to the client full point to graphic (100% of all field and virtual points) between the AHU system and the BMS head end dynamic graphics.

The AHU specialist shall provide full attendance during the 7 day environmental testing and shall provide the handover system reports that demonstrate that the AHU has performed as expected during this environmental test. These handover reports shall include all plant installation manuals, operating and maintenance manuals, hardware and soft copy of all software, panel wiring diagrams, system set points, system alarm set points.

The AHU specialist shall provide 3 return visits at 3 month intervals following practical completion where they shall re-demonstrate the operation of the AHU during winter, spring/autumn and summer modes. During this testing, the AHU specialist shall re-confirm all field to graphic points, all user interfaces and all system management functions. These visits are technical soft landing types and are not to be seen as time spent correcting construction snags and defects.

Operation

The BMS shall enable the ventilation plant to operate if the toilet core time clock is active or if any office AHU is running in occupancy mode. The AHU shall also run for (4) hours if the AHU BMS software hand/off/auto switch is set to hand.

The AHU specialist software shall enable the AHU when instructed by the BMS and assuming all interlocks are healthy. The BMS software interlock shall include fire healthy.

The AHU shall provide air at variable temperature dependent on the outside air temperature. The BMS shall calculate the supply air set point and send this to the AHU controller which in turn shall modulate the system as required.

If the outside air temperature is <(10)ºC then the supply air set point shall be (22)ºC and if the outside air temperature is >(17)ºC the supply air set point shall be (17)ºC. between these outside air temperatures, a linear progression of the supply air set point shall be provided.

The AHU controller shall modulate in sequence the heat recovery, heating/cooling DX system and electric reheater to maintain the supply air set point. During any defrost cycle the AHU the software shall ensure that the supply air temperature is never <(15)ºC.

When the system is shut down the DX unit and electric heater shall be disabled and the fans run on for a further (5) minutes.

The supply and extract fans shall run at constant speed.

The supply and extract fan shall be software interlocked such that the failure of one of the other shall stop the system operating. Where fan walls are provided a failure of any fan (unless this is provided with a mechanical nonreturn damper) shall shut the complete AHU down.

If the AHU is running and the refrigeration leak detection system is in alarm, the supply fan shall be disabled and the extract fan ran for a further 5 minutes and then shuts down.

Sensor fault

If the supply air temperature set point received at the AHU controller is out limits, then the AHU shall revert to a constant supply air temperature of (17)ºC.

If the AHU supply air temperature fails then the unit shall operate to a constant return air temperature of (20)ºC.

Graphic display

At the BMS head end supervisor the status of the AHU shall be available via the dynamic graphic. All field and virtual points shall be displayed and all shall be adjustable between limits.

The operating status of the EC fans shall be available either as a dialogue box or on the AHU user page.

The graphics shall display totally run time for each AHU. A level 3 user shall be able to reset this value back to 0.

System alarms

The BMS shall monitor the AHU for status and raise alarms on system mismatch. The alarm is raised shall be:

- AHU failing to run when commanded on.
- AHU running when not commanded on by BMS.
- Individual fan fault.
- ASHP fault.
- Dirty filter
- Heat recover unit fault
- Electric heater high temperature trip.
- Supply air temperature ±(3)ºC from set point.
- Any part of the AHU strategy operating in manual override. - This shall change the colour of the AHU controlled devices on the general graphic display.

Trend logs

The BMS specialist shall set the following trends to be logged:

- Fan change of state - running/not running.
- Supply air temperature
- Supply air set point.
- Return air temperature
- DX Cooling % output
- DX heating % out put

- Electric heater % output
- Electric heater off coil temperature.
- Outside air temperature.

These values shall be set for (10) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

2.3.8 12th Floor Conference Room Fresh Air Plant

The level 12 office is provided with an AHU (CAM) down unit in the same manner as all other offices. In this instance though fresh air is provided from a separate roof top mounted packaged air handling plant.

Fresh air is provided by a constant volume variable temperature packaged air handling plant. The system is enabled if the level 12 floor is in occupancy when the heat recovery, heating cooling systems are modulated in sequence to maintain the required supply air temperature. The controller shall be provided with a BACnet/IP connection that shall be connected to the sitewide BMS.

Construction remit

The office is ventilated by a packaged air handling plant located on the roof. The ventilation system comprise constant volume supply and extract fans, heat recovery systems, DX heating/cooling coils with integrally mounted air source heat pumps.

The power to the AHU panel shall be from the BMS provided mechanical services power board on the roof. The power to the fans, the ASHP and the heat recovery equipment shall be from the AHU packaged panel provided by the AHU specialist.

The AHU specialist supplier shall provide door interlocked form 2B type 2 control panel for the power section and a non-door interlocked form 1 panel for the control section. All LV services associated with the control section shall be housed within the power section, only ELV services shall be present in the control section. The outgoing ways to the air source heat pumps shall be provided with MID approved electrical meters with Modbus output, these shall be wired to a separate ELV section of the control panel.

The AHU specialist shall provide a refrigerant leak detection system within the AHU supply and extract systems.

The AHU specialist shall provide a back lit colour display system complete with touchscreen on the fascia of the AHU control panel. The screen shall provide dynamic graphic and text pages showing the plant status and allowing local manual integration and adjustment and have a minimum viewing dimension of 200 mm.

The AHU specialist shall provide power wiring to the fans, ASHP and the heat recovery systems from the power section of the control panel. Where multiple fans are provided each fan shall have individual electrical protection for the motor and the power feed.

Isolators shall be provided for each fan section, and the ASHP. Associated with this shall be lockstop buttons that shall shut power down to the complete AHU in the event of emergency. These lockstop buttons to be mounted alongside the AHU, local to the supply fan, local to the extract fan, and wired back by the AHU specialist to a contactor mounted in the power section of the mechanical services power board serving the AHU. This contactor shall have a 3 wire operated circuit with a reset button mounted

on the AHU control panel acting as the start and the lockstop button acting as the stop. The 3 wire latching relay system shall be held within the AHU panel.

The AHU specialist shall provide and install all controls instruments and actuators and wire these to the DDC control panel mounted in the control section.

The AHU specialist shall provide all interconnecting controls and network wiring inclusive of carrier systems between the AHU control panel and the air source heat pumps.

The AHU specialist shall provide and configure all necessary software, hardware and safety interlocking relay logic for the operation of the AHU. The controller shall be provided with BACnet/IP communications for connection to the sitewide BMS through which full read and write facilities shall be available.

The AHU specialist shall provide all hardwired safety interlocking that would include: supply and extract fans hardwired interlocked with damper proven open status, high pressure healthy, low pressure healthy, refrigeration leak detection system healthy, DX system hardwired interlocked with supply and extract fan flow proving status.

The AHU specialist shall provide all software interlocks that shall include: hardwired interlocks, AHU software HOA switch in hand or auto, no existing fan alarm.

A separate hardwired interlock shall be provided in the AHU control panel for connection to the sitewide fire alarm system.

The EC motors shall be provided with Modbus output that shall be connected to the AHU manufacturers provided controller and converted to BACnet to allow the BMS to read the fan status and in particular the running speed and the instantaneous power.

The EC motors shall be controlled by 0-10V hardwired signals from the AHU controller with hardwired fault and running status monitored.

The AHU specialist shall provide and configure all necessary software for the operation of the AHU and shall include setting to work testing and commissioning. Return visits shall be required during the future heating and cooling seasons.

Fresh Air AHU Setting to Work Testing and Commissioning

The AHU specialist shall provide full technical details including software, wiring diagrams, off site software and panel testing of the AHU, these shall be provided prior to delivery.

The AHU specialist supplier shall set to work test and commission the complete system of their supply. The commissioning shall include full integration with the sitewide BMS and the AHU specialist shall confirm, test and demonstrate to both the BMS specialist and later to the client full point to graphic (100% of all field and virtual points) between the AHU system and the BMS head end dynamic graphics.

The AHU specialist shall provide full attendance during the 7 day environmental testing and shall provide the handover system reports that demonstrate that the AHU has performed as expected during this environmental test. These handover reports shall include all plant installation manuals, operating and maintenance manuals, hardware and soft copy of all software, panel wiring diagrams, system set points, system alarm set points.

The AHU specialist shall provide 3 return visits at 3 month intervals following practical completion where they shall re-demonstrate the operation of the AHU during winter, spring/autumn and summer modes.

During this testing, the AHU specialist shall re-confirm all field to graphic points, all user interfaces and all system management functions. These visits are technical soft landing types and are not to be seen as time spent correcting construction snags and defects.

Operation

The BMS shall enable the ventilation plant to operate based on the demand from the office floor or if the site wide purge is active. The AHU shall also run for (4) hours if the AHU BMS software hand/off/auto switch is set to hand.

A building wide purge routine shall be provided that when active runs all office AHUs (CAM) units with a nominal return air set point of (21)ºC and dead bands of (±5)ºC. This routine is selectable from the BMS head end supervisor and runs for (4) hours and then reverts to normal automatic control. During this mode, the office AHUs also operate with a supply air set point of (21)ºC and dead bands of (±5)ºC.

The AHU specialist software shall enable the AHU when instructed by the BMS and assuming all interlocks are healthy. The BMS software interlock shall include fire healthy.

The AHU shall provide air at variable temperature dependent on the outside air temperature. The BMS shall calculate the supply air set point and send this to the AHU controller which in turn shall modulate the system as required.

If the outside air temperature is <(10)ºC then the supply air set point shall be (22)ºC and if the outside air temperature is >(17)ºC the supply air set point shall be (17)ºC. between these outside air temperatures, a linear progression of the supply air set point shall be provided.

The AHU controller shall modulate in sequence the heat recovery and heating/cooling DX system to maintain the supply air set point. During any defrost cycle the AHU the software shall ensure that the supply air temperature is never <(15)ºC.

When the system is shut down the DX unit shall be disabled and the fans run on for a further (5) minutes.

The supply and extract fans shall run at constant speed.

The supply and extract fan shall be software interlocked such that the failure of one of the other shall stop the system operating. Where fan walls are provided a failure of any fan (unless this is provided with a mechanical nonreturn damper) shall shut the complete AHU down.

If the AHU is running and the refrigeration leak detection system is in alarm, the supply fan shall be disabled and the extract fan ran for a further 5 minutes and then shuts down.

Sensor fault

If the supply air temperature set point received at the AHU controller is out limits, then the AHU shall revert to a constant supply air temperature of (17)ºC.

If the supply air temperature fails then the unit shall operate to a constant return air temperature of (20)ºC.

Global commands

The BMS specialist shall configure global commands at the head end supervisor for use both during commissioning and by the maintenance team. The global commands that shall be applied on a site wide basis include:

- set all AHU units to auto/off/on operation
- send a fixed outside air temperature between values of 10ºC and 17ºC

Whenever plant is set to 'ON' it shall run in that state for (4) hours and then revert to auto control.

Graphic display

At the BMS head end supervisor the status of each AHU shall be available via the dynamic graphic. All field and virtual points shall be displayed and all shall be adjustable between limits.

The operating status of the EC fans shall be available either as a dialogue box or on the AHU user page.

The graphics shall display totally run time for each AHU. A level 3 user shall be able to reset this value back to 0.

System alarms

The BMS shall monitor the AHU for status and raise alarms on system mismatch. The alarm is raised shall be:

- AHU failing to run when commanded on.
- AHU running when not commanded on by BMS.
- Individual fan fault.
- ASHP fault.
- Dirty filter
- Heat recover unit fault
- Supply air temperature ±(3)ºC from set point.
- Any part of the AHU strategy operating in manual override. - This shall change the colour of the AHU controlled devices on the general graphic display.

Trend logs

The BMS specialist shall set the following trends to be logged:

- Fan change of state - running/not running.
- Supply air temperature
- Supply air set point.
- DX Cooling % output
- DX heating % out put
- Outside air temperature.

These values shall be set for (10) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

2.3.9 Basement Ventilation

The basement is ventilated by constant volume variable temperature packaged air handling plant. The system is enabled to suit the basement time clock and the heat recovery, heating cooling systems are modulated in sequence to maintain the required supply air temperature. The AHU package controller is provided with a BACnet/IP interface to the sitewide BMS.

Construction remit

The basement is ventilated by a packaged air handling plant located in the basement. The ventilation system comprises constant volume supply and extract fans, heat recovery systems, DX heating/cooling coils with integrally mounted air source heat pumps and where necessary electric reheaters.

The power to the AHU panel shall be from the Electrical specialist supplied switchboard. The power to the electric heater, the fans, the ASHP and the heat recovery equipment shall be from the AHU packaged panel provided by the AHU specialist.

The AHU specialist supplier shall provide door interlocked form 2B type 2 control panel for the power section and a non-door interlocked form 1 panel for the control section. All LV services associated with the control section shall be housed within the power section, only ELV services shall be present in the control section. The outgoing ways to the electric heater and the air source heat pumps shall be provided with MID approved electrical meters with Modbus output, these shall be wired to a separate ELV section of the control panel.

The AHU specialist shall provide a contactor hardwired interlocked with the high temperature cut out and thyristor for the electric reheater and mount these in the power section of the control panel.

The AHU specialist shall provide a refrigerant leak detection system within the AHU supply and extract systems.

The AHU specialist shall provide a back lit colour display system complete with touchscreen on the fascia of the AHU control panel. The screen shall provide dynamic graphic and text pages showing the plant status and allowing local manual integration and adjustment and have a minimum viewing dimension of 200 mm.

The AHU specialist shall provide power wiring to the fans, electric heater, ASHP and the heat recovery systems from the power section of the control panel. Where multiple fans are provided each fan shall have individual electrical protection for the motor and the power feed.

Isolators shall be provided for each fan section, the heat recovery section, the ASHP and the electric heater. Associated with this shall be lockstop buttons that shall shut power down to the complete AHU in the event of emergency. These lockstop buttons to be mounted alongside the AHU, local to the supply fan, local to the extract fan, and wired back by the AHU specialist to a contactor mounted in the power section of the mechanical services power board serving the AHU. This contactor shall have a 3 wire operated circuit with a reset button mounted on the AHU control panel acting as the start and the lockstop button acting as the stop. The 3 wire latching relay system shall be held within the AHU panel.

The AHU specialist shall provide and install all controls instruments and actuators and wire these to the DDC control panel mounted in the control section.

The AHU specialist shall provide all interconnecting controls and network wiring inclusive of carrier systems between the AHU control panel and the air source heat pumps.

The AHU specialist shall provide and configure all necessary software, hardware and safety interlocking relay logic for the operation of the AHU. The controller shall be provided with BACnet/IP communications for connection to the sitewide BMS through which full read and write facilities shall be available.

The AHU specialist shall provide all hardwired safety interlocking that would include: supply and extract fans hardwired interlocked with damper proven open status, high pressure healthy, low pressure healthy, refrigeration leak detection system healthy, DX system hardwired interlocked with supply and extract fan flow proving status, electric reheat hardwired interlocked with supply fan flow proving status and high temperature cut out.

The AHU specialist shall provide all software interlocks that shall include: hardwired interlocks, AHU software HOA switch in hand or auto, no existing fan alarm.

A separate hardwired interlock shall be provided in the AHU control panel for connection to the sitewide fire alarm system.

The EC motors shall be provided with Modbus output that shall be connected to the AHU manufacturers provided controller and converted to BACnet to allow the BMS to read the fan status and in particular the running speed and the instantaneous power.

The EC motors shall be controlled by 0-10V hardwired signals from the AHU controller with hardwired fault and running status monitored.

The AHU specialist shall provide and configure all necessary software for the operation of the AHU and shall include setting to work testing and commissioning. Return visits shall be required during the future heating and cooling seasons.

Basement AHU Setting to Work Testing and Commissioning

The AHU specialist shall provide full technical details including software, wiring diagrams, off site software and panel testing of the AHU, these shall be provided prior to delivery.

The AHU specialist supplier shall set to work test and commission the complete system of their supply. The commissioning shall include full integration with the sitewide BMS and the AHU specialist shall confirm, test and demonstrate to both the BMS specialist and later to the client full point to graphic (100% of all field and virtual points) between the AHU system and the BMS head end dynamic graphics.

The AHU specialist shall provide full attendance during the 7 day environmental testing and shall provide the handover system reports that demonstrate that the AHU has performed as expected during this environmental test. These handover reports shall include all plant installation manuals, operating and maintenance manuals, hardware and soft copy of all software, panel wiring diagrams, system set points, system alarm set points.

The AHU specialist shall provide 3 return visits at 3 month intervals following practical completion where they shall re-demonstrate the operation of the AHU during winter, spring/autumn and summer modes. During this testing, the AHU specialist shall re-confirm all field to graphic points, all user interfaces and all system management functions. These visits are technical soft landing types and are not to be seen as time spent correcting construction snags and defects.

Operation

The BMS shall enable the ventilation plant to operate based on the basement time clock. The AHU shall also run for (4) hours if the AHU BMS software hand/off/auto switch is set to hand.

The AHU specialist software shall enable the AHU when instructed by the BMS and assuming all interlocks are healthy. The BMS software interlock shall include fire healthy.

The AHU shall provide air at variable temperature dependent on the outside air temperature. The BMS shall calculate the supply air set point and send this to the AHU controller which in turn shall modulate the system as required.

If the outside air temperature is <(10)ºC then the supply air set point shall be (22)ºC and if the outside air temperature is >(17)ºC the supply air set point shall be (17)ºC. between these outside air temperatures, a linear progression of the supply air set point shall be provided.

The AHU controller shall modulate in sequence the heat recovery, heating/cooling DX system and electric reheater to maintain the supply air set point. During any defrost cycle the AHU the software shall ensure that the supply air temperature is never <(15)ºC.

When the system is shut down the DX unit and electric heater shall be disabled and the fans run on for a further (5) minutes.

The supply and extract fans shall run at constant speed.

The supply and extract fan shall be software interlocked such that the failure of one of the other shall stop the system operating. Where fan walls are provided a failure of any fan (unless this is provided with a mechanical nonreturn damper) shall shut the complete AHU down.

If the AHU is running and the refrigeration leak detection system is in alarm, the supply fan shall be disabled and the extract fan ran for a further 5 minutes and then shuts down.

Shower area reheat

The AHU provides tempered air to the shower area where for each of the male and female spaces LTHW reheat duct mounted coils are provided.

The BMS specialist shall provide 2 port modulating valve, space temperature and supply air temperature sensor and wire these to the local BMS control panel.

The space temperature shall monitor the local temperature with a user adjustment of (+/-3)ºC. from the nominal set point of (23)ºC. This set point shall reset to 0 offset at midnight but can be adjusted by a level 3 user (+/-3)ºC.

The space temperature sensor shall reset between limits (19 to 28)ºC. the supply air temperature sensor to maintain the room set point. The supply air temperature sensor measured value shall modulate the heating valve to a PI loop to achieve the supply air set point.

Sensor fault

If the supply air temperature set point received at the AHU controller is out limits, then the AHU shall revert to a constant supply air temperature of (17)ºC.

If the AHU supply air temperature fails then the unit shall operate to a constant return air temperature of (20)ºC.

if the shower room temperature sensor is out of limits, then the supply air temperature sensors shall have a set point of 25°C.

If the shower room supply air temperature sensor is out of limits, then the heater battery shall modulate to maintain the room set point.

Graphic display

At the BMS head end supervisor the status of the AHU shall be available via the dynamic graphic. All field and virtual points shall be displayed and all shall be adjustable between limits.

The operating status of the EC fans shall be available either as a dialogue box or on the AHU user page.

The graphics shall display totally run time for each AHU. A level 3 user shall be able to reset this value back to 0.

System alarms

The BMS shall monitor the AHU for status and raise alarms on system mismatch. The alarm is raised shall be:

- AHU failing to run when commanded on.
- AHU running when not commanded on by BMS.
- Individual fan fault.
- ASHP fault.
- Dirty filter
- Heat recover unit fault
- Electric heater high temperature trip.
- Supply air temperature ±(3)ºC from set point.
- Any part of the AHU strategy operating in manual override. - This shall change the colour of the AHU controlled devices on the general graphic display.

Trend logs

The BMS specialist shall set the following trends to be logged:

- Fan change of state - running/not running.
- Supply air temperature
- Supply air set point.
- Return air temperature
- DX Cooling % output
- DX heating % out put
- Electric heater % output
- Electric heater off coil temperature.

- Outside air temperature.
- Shower area and female temperatures
- shower reheat duct valve positions
- shower supply air temperature down stream of reheater.

These values shall be set for (10) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

2.3.10 Basement Smoke Extract

The basement is provided with smoke extract using 2 separate systems. The systems run only in smoke but provided with BMS high level outputs for test purposes. Associated with the basement smoke extract are motorised smoke fire dampers, these are controlled and monitored by the separate specialist supplied smoke damper control system.

Construction remit

The basement is provided with 2 sets of duty standby extract fans, these fans operate for smoke control only.

The electrical specialist shall provide an ATS for a smoke fan powered from the electrical distribution system. The BMS specialist shall provide power wiring from the isolator to the IP 54 rated wall mounted inverters associated with each fan.

The BMS specialist shall provide power wiring from one of the ATS units to the form 1 BMS provided control panel that shall be complete with a UPS both for communications and control/monitoring of the smoke fans in the event of local power failure.

The ATS, inverters and control panel shall be located within a 2 hour fire rated ventilated enclosure. The ventilation grilles shall have intumescent fire sealing. The enclosure complete with access doors shall be costed by the MEP contractor. The construction may be by the main contractor but costs shall be in this package for future transfer.

Power and controls wiring shall be category 3 to BS 8519.

The fan smoke isolation dampers shall be controlled and managed by the smoke damper control system however, the BMS shall monitor the open/close status of the damper and transmit this back to the smoke damper control system hardwired interposing relays held within the BMS control panel.

Isolators shall be provided for each fan that shall be monitored for status by the BMS. The status of the inverter isolators shall be monitored via the inverter fault signal that shall be active when no power is available at the inverter. These isolators are not required if the inverter is within 2 meters of the power board within which the MCBs shall be lockable in the off position.

The BMS specialist shall provide and install all controls instruments and actuators and wire these to the DDC control panel mounted in the control section.

The BMS specialist shall provide and configure all necessary software, hardware and safety interlocking relay logic for the operation of the basement smoke system. The controller shall be provided with BACnet/IP communications. Hardwired connections shall be provided to the inverters for start/stop and plant status in a fire mode.

The BMS specialist shall provide all hardwired safety interlocking that would include: fans hardwired interlocked with other paired drive not running, fire healthy, low and high pressure switches healthy. The low and high pressure switches shall be linked out whenever the system is operating in smoke extract mode.

The BMS specialist shall provide the software interlocks that shall include: hardwired interlocks and fan software HOA switch in hand or auto, no existing fan alarm.

The fire alarms shall provide fire healthy and smoke extract required I/O cards alongside the BMS control panel. This shall be wired by the BMS specialist to the control panel in category 3 cabling.

The inverters shall be provided with BACnet/MSTP to allow the BMS to read the fan status, the running speed and the instantaneous power.

The inverters shall be controlled in a fire mode by digital inputs direct to the inverter for fire operation and override electronic safety circuits. The hardwired relay logic shall be constructed to accommodate 4 different fan speeds in a smoke extract mode.

The BMS specialist shall provide configure all necessary software for the operation of the system and shall include setting to work testing and commissioning.

The BMS specialist shall provide volt free contacts within the control panel that can be monitored remotely by the fire alarm system that show fans running and fan fault status.

Operation fire

In the event of a fire alarm signal being received at the control panel the fans shall be stopped if they are running.

The system duty fan selected as SF/B/01 and SF/B/03 shall be started, assuming all interlocks are healthy when a smoke extract command is received at the control panel. When this command is received the two fans shall be enabled through hardwired interlocks. The standby fan SF/B/02 or SF/B/02 shall be started through hardwired interlocks if the other fan in the system has failed to run for (30)seconds through a hardwired timer relay logic. Once the second fan has been enabled it shall continue to operate irrespective of the status of the original duty fan.

The fan speed shall be hard coded within the inverter and the fan shall be started through hardwired interlock and hardwired fire command signal shall be given to the inverter to override normal electronic safety interlocks.

When the smoke extract required signal is absent the fans shall be stopped, the isolation dampers closed and the timers reset. The system shall return to normal ventilation only when the fire alarm signal as return to healthy state.

Remote monitoring

The BMS specialist shall provide volt free contacts in the fan control panel to indicate that either smoke fan is operating or that either fan as a fault. These contacts shall be monitored by the fire alarm system and displayed on the indicator panel in the fire command centre.

Graphic display

At the BMS head end supervisor the status of the system: fans, and power via monitoring the ATS shall be available via the dynamic graphic.

The operating status of the inverters shall be available either as a dialogue box or on the fan user page.

The graphics shall display totally run time for each fan. A level 3 user shall be able to reset this value back to 0.

System alarms

The BMS shall monitor the fans for status and raise alarms on system mismatch. The alarm is raised shall be:

- Fan failing to run when commanded on.
- Fan running when not commanded on by BMS.
- Inverter fault. - out of auto, high temperature, no power available.
- Fan isolator open.
- Any part of the system strategy operating in manual override. - This shall change the colour of the system controlled devices on the general graphic display.

Trend logs

The BMS specialist shall set the following trends to be logged:

- Fan change of state - running/not running.
- Smoke extract active
- fire alarm active

These values shall be set for (10) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

2.3.11 Bin Store

The Bin storeroom is ventilated by a packaged MVHR unit complete with integral electric reheater, thermal controls and safety interlocks.

The ventilation plant is enabled whenever the Bin store clock is active.

The unit when running provide air at variable temperature to maintain the room air set point measured by the BMS mounted controller.

Controls Hardware

The MEP specialist shall provide the MVHR unit with integral motor protection and ELV terminals for connection to the BMS.

The BMS specialist shall provide the thyristor and mount this in the power section of MCC-B-1.

The BMS specialist shall provide all controls instruments actuators such as the thyristor, supply air temperature sensor, return air temperature sensor, high temperature cut out. The thyristor should be complete with a contactor that shall be hardwired interlocked with the supply fan air flow proving switch.

The MEP specialist shall provide ELV terminals for connection of the fire alarm system direct to the fan controller.

The MEP specialist shall provide a high-level interface BACnet/MSTP for connection to the sitewide BMS.

The BMS specialist shall carry out all interconnecting cabling between the MVHR instruments actuators and the MVHR control panel.

The BMS specialist shall provide all software interlocking that would include hardwired interlocks, MVHR software HOA switch, and no existing fan alarm. If any of these are in a fault mode then the MVHR shall not be able to operate. Where software switches are provided if these are in the “HAND” mode then the unit shall be able to run assuming all hardwired interlocks are healthy. The system shall revert to auto after 4 hours, this time limit is only adjustable in software configuration mode.

The fans require a manual speed control when operating in a manual mode. This manual speed control limited to a minimum of 20 Hz shall be available to the user through a user adjustable GUI knob displayed on the BMS head end supervisor and at the plant control panel.

The major alarms when active shall illuminate the panel alarm lamp. When the alarm reset button is operated ALL existing alarms within this local controller shall be cleared.

The BMS specialist shall monitor the electrical meter that shall form part of the tenant billing system and energy monitoring system.

Operation

The unit shall be enabled whenever the Bin store time clock is active, or if the MVHR BMS software HOA switch is in the hand position. The MVHR unit shall run until the end of occupancy when the electric heater shall be disabled and the fan run on for a further (5) minutes.

When the plant is required to run the BMS will enable the unit and unit shall operate for its interlocked control system assuming all interlocks are healthy.

Hardwired Interlocks

The supply fan hardwired interlocks within the integral controller shall include: fire alarm healthy. The software interlock within the BMS controller (with suitable time delays) shall include hardwired no existing fan alarm, the MVHR software switch in either hand or auto.

The BMS specialist shall include hardwired interlocks for the electric heater. The heaters shall be isolated electrically if either the manual reset high temperature cut out is active or if there is no proven airflow in the supply system.

Motor Fault

The BMS shall monitor the fan status via a hardwired connection to the integral motor controller and separate fan differential pressure switches.

If the fan has been called to run and the fan proven running has not made after a suitable grace time then the unit shall shut down and an alarm raised.

Plant Off State

When the MVHR is required to shut down the heaters shall be disabled and the fans run for a further 5 minutes.

System Thermal Control

The integral MVHR controller shall modulate the summer bypass damper and the BMS shall modulate the reheater supply unit to maintain the required supply air temperature set point.

The BMS shall set the supply air set point between adjustable limits of (15 to 25)ºC.

Fan Speed Control

The fans shall run at the speed determined during commissioning.

Fire Mode

In a fire mode the MVHR shall shut down through hardwired interlocks.

Graphic Display

At the BMS head end supervisor the BMS specialist shall provide full dynamic graphic of the MVHR allowing display and interaction of every field and virtual point.

The graphic shall be held within the BMS server and automatically downloaded on changes to the MVHR control panel. This will allow user interface if the converged network is in active.

All operating set points shall be held at the local BMS controller with adjustments through the supervisors or locally at the controller.

The graphical display shall include all energy monitoring associated with the MVHR.

Sensor Faults

The control sensors shall be monitored and if out of range, then alternative sensors shall be utilised for the control strategy.

- If the MVHR supply air temperature is out of range then the electric reheater shall be disabled.

System Alarms

The BMS shall monitor the ventilation system for status and raise alarms on system mismatch with a suitable grace time.

The critical alarms, that shall be indicated on the MVHR graphic and in the alarm list, illuminate the MVHR fault lamp and be issued as an email shall be:

- MVHR fault
- HTCO trip

All critical alarms shall auto reset at midnight, shall reset if the alarm reset button on the graphic is operated and shall reset if the alarm reset button is operated on the BMS controller.

The maintenance alarms, that shall be indicated on the AHU graphic and when in the alarm list shall be:

- Filter dirty.
- Supply air temperature ± 5ºC from set point
- Fan speed manually overridden.

- Sensor out of range.

All maintenance alarms shall be cleared when the state returns to normal.

Trend Logs

The BMS specialist shall set the following trends to be logged:

- Fan change of state - running/not running
- Supply air set point
- Supply air measured temperature
- heater electrical power

These values shall be set for (15) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

2.3.12 Staircase and Firefighting Lobby Smoke Control Systems

The smoke control systems shall be provided by specialist supplier complete power and control panel and all installation, wiring, instruments, actuators and fan inverters.

The specialist supplier shall provide a user control panel in the ground floor lobbies and shall provide a BACnet interface for high level connection to the sitewide BMS.

All controls and power wiring shall be category 3 to BS 8519.

2.3.13 Smoke Damper Control System

The smoke damper control system generally located in the basement shall be supplied and installed set to work tested and commissioned by specialist smoke damper control supplier.

The dampers shall be provided with appropriate firebox protection to the actuators and the damper interface units shall be mounted alongside the actuators.

The specialist shall provide the interconnecting network from the damper interface units to the smoke control panel.

The smoke damper control panel shall be located in the fire command centre shall indicate the open closed position of every smoke damper, status of the smoke fans, the status of the power to the smoke fan control panel.

The electrical specialist shall provide power to the damper interface units from the life safety control panel.

The smoke damper control specialist shall provide a BACnet interface for connection to the sitewide BMS. Through this gateway the BMS shall receive the status of all connected plant and equipment. The BMS specialist shall provide full dynamic graphic of all field and virtual points associated with the smoke damper control system and the smoke damper control specialist shall test, verify and confirm 100% of the data showing on the BMS supervisor. The smoke damper specialist to confirm this with the BMS specialist and once to the client.

All controls and power wiring shall be category 3 to BS 8519.

2.3.14 Local Cooling Systems

The LV switch rooms and UPS, management space shall be provided with local cooling using DX fan coil units and external condensers. The unit shall be provided with integral controllers with the fan coil units, condensers and controllers networked back to a specialist provided colour backlit user interface.

The BMS specialist shall provide a DX/BACnet gateway and shall monitor all field and virtual points and display these on the BMS head end supervisor. The VRF specialist shall verify test and confirm every field and virtual point to the BMS head end supervisor. This demonstration of 100% of points shall be repeated to the client by the VRF specialist.

The DX specialist shall provide all control and duty sharing of the fan coil units and condensers for the switch rooms and the UPS space.

The BMS specialist shall provide power to the external air source heat pumps from BMS Supply panels. The electrical contractor shall provide power to the internal fan coil units and the VRF controllers.

The refrigerant leak detection system shall be provided by a specialist and monitored by the BMS for fault.

2.3.15 Mezzanine Office Fan Coil Units

The mezzanine offices are provided with 4 pipe fan coil units that have return air temperature sensors. The fan coils are enabled to suit the BMS provided optimiser and the area is provided with LTHW & CHW heat meters that are networked to the BMS.

Construction Remit

The BMS specialist shall provide all controllers, control transformer, supply and return air temperature sensors, 2 port (0-10v) PICV modulating valves and actuators for the fan coil control system. This equipment shall be free issued to the fan coil unit manufacturer for mounting and wiring within the appropriate control panels. These panels shall be provided by the FCU manufacturer.

The controls transformer and all LV power shall be in a separate door interlocked form 1 control panel mounted on the side of the fan coil unit. The ELV DDC controller shall be mounted in a separate non-door interlocked panel into which all ELV wiring shall be marshalled. This is a requirement to have two separate panels (one with LV and one with ELV services) to facilitate live working during testing, commissioning and maintenance.

The FCU manufacturer shall provide a 3 meter trailing fan coil unit power lead, from the power section, that shall be connected to the soffit mounted unswitched fused spur by the electrical contractor.

The FCU manufacturer shall install the supply air temperature sensor in the discharge of the FCU and connect all actuators and the control signal for the fans to the DDC controller. The return air temperature sensor with a 5 meter trailing lead shall be connected to the controller and coiled up. All cabling associated with the equipment both within the panel and the ceiling void shall be LSOH (PVC shall not be acceptable).

The FCU shall be provided with an integral control/monitoring card that shall be used to start/stop the fan, provide speed control and provide either a running or a fault signal.

The FCU shall have (where necessary) a condensate pump with automatic integral operation.

System Operation

The offices shall be air conditioned by fan coil units that are enabled to suit the local system optimiser. The optimiser shall enable the fan coil units for optimised warm up and cool down, occupancy, low space temperature protection and high space temperature protection.

The optimiser shall enable the fan coil units for warm up to achieve space temperature set point of (20)ºC at occupancy time. During this period the fan coil units shall run at full speed with the heating valve modulated to maintain the return air set point of (25)ºC. If any FCU achieves its nominal space set point (22)ºC then normal operation shall commence however, the chilled water valve shall remain closed throughout any warmup period. The warmup period shall have a maximum of (2)hours search time.

The optimiser shall enable the fan coil units for low space temperature protection operating the fan coils as for warm up if the space temperature is <(14 ± 2)ºC.

During the occupancy period the fan coil return air temperature sensor shall be used to modulate in sequence with a dead band of (1)ºC and PI control the heating and the cooling coil.

The supply air temperature sensor shall be used to override the control output to the cooling and heating valve to maintain a minimum supply air temperature of (14)ºC. and a maximum supply air temperature of (30)ºC. These values be manually adjustable on a global command from the BMS head end supervisor between limits of ± 5ºC.

Alternatively, the BMS specialist shall provide cascade control for the fan coil unit such that the supply air temperature is reset between limits 14° C to 30° C based upon the heating/cooling demand from the return air sensor and the supply air temperature sensor controls in sequence the heating and cooling valves to achieve the supply air set point.

If at any time the space temperature monitored by the common space temperature sensor is >(28)ºC then the fan coil units shall be set to operate at full speed. The fan coil cooling valves shall be modulated to provide a (20)°C supply air temperature and the system remain operational until the common space temperature sensor is <(24)ºC. The set point for the upper and lower limit room temperatures shall be adjustable at the BMS head end supervisor ±(3)ºC.

Each fan coil unit shall have a nominal set point and adjustable offset set point all of which can be manipulated through the BMS head end supervisor. The nominal set point (21)ºC can be adjusted by a level 3 user by (±2)ºC, this value adjusted remains fixed. The adjustable offset set point can be altered by any user by (±3)ºC. from either the BMS head end, the user interface on the floor master controller or the room mounted user interface. This offset however it reverts to 0 at 02.00 every day.

To accommodate excessive external temperatures the BMS shall automatically reset the fan coil unit nominal set point such that for each 1ºC that the outside air temperature is above 25ºC (adjustable at the head end supervisor 25°C to 35°C) the nominal set point shall be increased by 1°C. And for each 1ºC that the outside air temperature is below 5ºC (adjustable at the head end supervisor 5ºC down to -10ºC) the nominal set point shall be reduced by 1°C. The adjustment limit shall however not allow the return/room air set point to rise above 26ºC or fall below 19ºC. When this auto reset is active Indication shall be provided on the BMS head end supervisor on the floor graphic displays.

The fan coil unit shall generally operate at a fixed speed. The BMS specialist shall set the fan speeds for each fan coil unit individually (at possible different values determined during commissioning) based upon a minimum speed of (60)%. Each fan coil unit shall have a user adjustable value above that set point.

Each fan coil unit shall be provided with the software auto/off/on switch that is adjustable from the BMS head end supervisor. If ON is selected then the FCU shall operate normally for a maximum of (4) hours and return to auto.

Sensor Failure

If the return/room air sensor fails then the FCU shall operate to a constant supply air temperature of (17)ºC.

Condensate Pump Fault

If there is a condensate pump fault then the FCU shall continue to operate however the cooling valve shall remain closed.

Floor Plant Extension Button

Generally, the fan coil unit operate to the plant optimiser however tenant floor plant extension buttons indicated on the floor graphic shall be provided. When this push button has been pushed the fan coil units shall run under normal control for (4) hours and then revert to auto control. The appropriate office ventilation plant and the general building toilet extract systems shall be enabled at this time.

Global Commands

The BMS specialist shall configure global commands at the head end supervisor for use both during commissioning and the maintenance team. The global commands that shall be applied on a site wide basis include:

- Set all fan coil units to auto/off/on operation
- Reset all nominal temperature set point between the value of (21 to 25)ºC
- Reset all offsets set points to 0
- Reset all fan coil unit fans to (60)% minimum speed
- Set the cooling valve to fully open, fully closed or auto control
- Set the heating valve to fully open, fully closed or auto control.

Whenever plant is set to ‘ON’ it shall run in that state for (4) hours and then revert to auto control.

Graphic Display

At the BMS head end supervisor the status of each fan coil unit shall be available via the dynamic graphic. However, this information shall also be provided in tabular form such that the status of individual fan coil unit items can be seen at the same time on a floor by floor basis.

Fan coil unit	Status	Fan speed	Nominal Set point	Offset adjustment	Actual set point	Cooling valve output	Heating valve output	Return/space temperature	Supply air temperature	Condensate pump fault	Maintenance routine failure	Fan alarm
Reference number	On/off	%	°C	± °C	°C	%	%	°C	°C			
Reference number	On/off	%	°C	± °C	°C	%	%	°C	°C			

The dynamic graphic shall be a floor plan that shall display on the first overview the return air /space temperature measured and the reference of the fan coil unit.

Drilling down from this overview the individual status of each fan coil shall be displayed as a dynamic graphic. On this graphic it shall be possible to adjust the fan speed, adjust the return/space temperature set point and manually control all of the analogue and digital outputs.

System Alarms

The BMS shall monitor the fan coil unit for status and raise alarms on system mismatch. The alarms raised shall be:

- Fan failing to run when commanded on
- Condensate pump fault
- Return/space temperature >(± 3)°C from set point. This value shall be automatically adjusted based upon the nominal set point and the offset being applied
- Supply air temperature > (2)°C above or below the upper and lower limit supply air set point
- Any part of the fan coil unit strategy operating in manual override. - This shall change the colour of the fan coil unit on the general graphic display.

Trend Logs

The BMS specialist shall set the following trends to be logged:

- Fan change of state - running/not running
- Supply air temperature
- Return/space temperature
- Return/space set point. This shall be the actual value required not the nominal or the offset but the actual value.
- Heating valve position
- Cooling valve position

These values shall be set for (10) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

Fan Coil Maintenance Strategy

The BMS specialist shall provide and configure software for a fan coil maintenance strategy program. When this maintenance strategy is active the fan coil unit shall be enabled and the return air set point shall be set to (14)ºC. The system shall run for (10) minutes and then return to auto for (5) minutes. The return air set point shall be set to (24)ºC and the system shall run for a further (10) minutes and then return to auto for (5) minutes and then revert to off.

An automatic report shall be generated for all fan coil units generally set out as the previously described general table for fan coil unit information. The maintenance fail alarm shall be active if during the cooling mode the supply air temperature has not fallen below (16)ºC or in the heating mode risen above (25)ºC.

The routines shall be set to allow the FM team to select from a single click on the general adjustments page.

The selection of this routine is mainly carried out by the FM team however, the general building alarm shall be raised if any area has not had a test in the previous 800 hours.

Valve Exercise Routine

At 02.00 each morning the heating and cooling valve shall be opened and closed fully once.

Water Quality Circulation Routine

Each fan coil unit cooling and heating valve shall be opened once per day for (1) hour and the appropriate circulation pumps operate at normal speed. This action should generally take place at (04.00) although this time shall be adjustable by the user. The action to start this strategy shall be sent from the tenants BMS to the landlords BMS.

2.3.16 Shower Area Underfloor Heating System

Within the shower area space heating is provided through underfloor pipework that is connected to an underfloor heating manifold complete with circulating pump and thermal control valve. The system is available for continuous operation and maintains an out of hours temperature of (15)ºC. and operating space temperature of (22)ºC.

When operating the duty pump shall be enabled and run at variable volume to suit the sensorless integral pump control. The flow temperature shall be achieved by modulation of the mixing valve and the individual system valves shall be open or closed to maintain the local space temperature or the maximum/minimum floor temperature.

Heat meters are provided for the underfloor heating system that shall be networked to the BMS.

Controls Hardware

The BMS specialist shall provide the 3 port 24 Volt modulating valve complete with actuator, the modulating (although these will be two position) 2 port 24 Volt PICV valves for the distribution system and floor temperature and black bulb space temperature sensors. These and the controls instruments associated with the pump set shall be wired to a BMS provided form 1 control panel.

The BMS specialist shall provide power to the pump sets from the BMS provided mechanical services power board. The pump shall be hardwired interlocked with the secondary side high temperature cut out.

The plant status and plant HOA switches shall form part of a GUI displayed on an android style backlit colour display panel.

The MEP specialist shall provide the distribution pump sets with integral motor protection and controls for sensorless speed operation and extra low voltage connections for integration to the sitewide BMS.

System Operation

Low space temperature

The system shall be set to operate at any time if the space temperature is <(13)ºC in this mode the duty pump shall be enabled assuming all interlocks are healthy, the 3 port valve modulated to achieve the flow temperature and the underfloor heating valves open fully. The system shall revert to off when the space temperature has risen to (15)ºC

Occupancy

During occupancy the system shall run to maintain a nominal space temperature of 22°C adjustable by the user (± 3)ºC When the floor valves are opened, they shall remain open until the nominal space temperature is achieved when they shall close.

The duty pump also runs on a daily basis to provide water quality circulation through the systems.

The pumps that operate duty/standby shall be enabled whenever a heating demand is active, water quality routine and if the pump HOA software switch is in the hand or auto mode.

Normal Operation

During occupancy, the system shall run to maintain a nominal space temperature of 22°C When the floor valves are opened for heating, they shall remain open until the nominal space temperature is achieved when they shall close.

The nominal space set point shall be user adjustable via a wall mounted colour backlit device and through the BMS supervisor. The set point can be adjusted (± 3)ºC that reverts to 0 offset at midnight. A level 3 user has the ability to reset the nominal set point (± 3)ºC that does not have a midnight reset.

When the heating demand is active the duty circulation pump shall be enabled, assuming all interlocks are healthy. The pump shall run under its integral sensorless control system to maintain the required pump speed.

The secondary heating valve shall be modulated to maintain the secondary flow temperature set point nominally (50)ºC This temperature shall be reduced in with a PI loop towards 40°C if any floor sensor measured temperature is >(35)ºC. The flow temperature shall revert to (50)ºC at the end of occupancy or when all floor sensors are <(30)ºC.

BMS HOA Software

If the pump software switch is in the Hand mode the pump shall run assuming all hardwired interlocks are healthy for (4) hours and revert to auto.

If the pumps are operated in this mode the underfloor valves are open fully.

Water Quality routine

If the heating water quality routine is active the duty pump set is enabled and operates under normal pressure control with pump changeover as necessary and the flow temperature shall be fixed at (20)°C. The underfloor valves open fully, unless the system is operating in normal mode. The operating procedure shall be disabled if the distribution valves have been >(50)% open for >(1) hour in the previous (18) hours.

The valves remain open until the water quality routine is disabled or the plant is required to operate normally. The water quality routine operate under a fixed time clock that is nominally set for (04.00)am for (0.5) hour on a daily basis.

The calendar is fully adjustable at the BMS head end supervisor however, if the routine has not operated in the previous (72) hours a BMS alarm shall be raised. The water quality routine shall be held off if stage 1 frost protection is active.

Pump Interlocks

The pumps shall be hardwired interlocked with the pressurisation unit low pressure healthy and the high temperature cut out healthy. The software interlocks shall include the hardwired interlocks, no existing pump alarm, pump BMS HOA switch in hand or auto, PHX system BMS HOA switch in the hand or auto mode.

Sensor faults

The control sensors shall be monitored and if out of range, then alternative sensors shall be utilised for the control strategy.

- If the room air temperature sensor is out of range, then a temperature of 16oC shall be assumed.
- If the secondary side flow temperature sensor is out of range the control shall revert to secondary side return temperature fixed set point of (45)oC for the heating.

System Alarms

The BMS shall monitor the system for status and raise alarms on system mismatch with a suitable grace time.

The critical alarms, that shall be indicated on the pump graphic and in the alarm list.

- Pump failing to run when commanded on

The maintenance alarms, that shall be indicated on the pump graphic and when in the alarm list shall be:

- High temperature cut out trip.
- Pump speed manually overridden
- Pump in manual control
- temperature sensor out of range

Trend Logs

The BMS specialist shall set the following trends to be logged:

- Pump change of state - running/not running

- System flow temperature set point
- System flow temperature
- 3 port BMS output position.
- Energy meter entering water temperature
- Energy meter leaving water temperature
- Energy meter flow rate
- Instantaneous heat energy
- Accumulative heat energy
- space temperatures
- floor temperatures

These values shall be set for (15) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

2.3.17 Trench Heating and Cooling

The MEP specialist shall provide trench heating/cooling to the entrance Hall be controlled and managed by the sitewide BMS.

The BMS specialist shall provide the 2 port modulating PICV valves, wall mounted temperature sensor and cooling and heating meters for the system.

Operation

The heating system shall be enabled if the outside air temperature is <(10)ºC. and the heating valve opened fully. The fans shall be enabled at variable speed for minimum through to maximum at on outside air temperature of (3)ºC.

The heating systems shall be enabled if any time the space temperature is <(16)ºC. When the system shall run with the heating valve opened and the fan at full speed until the space temperature is >(18)ºC.

The cooling systems shall be enabled any time the space temperature is >(25)ºC. When the cooling valve shall be open fully and the fan speed at full speed until the space temperature is <(23)ºC.

The heating and cooling valves shall be opened once per day during the building water flush cycle.

System Alarms

The BMS shall monitor the fan coil unit for status and raise alarms on system mismatch. The alarms raised shall be:

- space temperature <(10)ºC. or >(30)ºC.
- Any part of the unit strategy operating in manual override. - This shall change the colour of the fan coil unit on the general graphic display.

Trend Logs

The BMS specialist shall set the following trends to be logged:

- space temperature

- outside air temperature
- Heating valve out put
- Cooling valve output
- fan speed output

These values shall be set for (10) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

2.3.18 Staircase Temperature Control

The MEP specialist shall provide radiators on the staircase complete with thermostatic regulating valves. Openable windows are also provided controlled from the window automation system with commands from the BMS.

The BMS specialist shall provide the 2 port modulating PICV isolation valves, wall mounted temperature sensor and heat meters for the system that shall be connected to the BMS

Heating Operation

The isolation valves shall be opened whenever the outside air temperature is <(15)ºC. which shall be user adjustable (± 5)ºC. the valve shall remain closed if the staircase temperature is > (21)ºC at either the bottom of the top.

Window operation

The BMS shall open the staircase windows if the space temperature is >(23 ± 3)ºC. the window shall close if the outside conditions are either raining on wind speed > TBA.

System Alarms

The BMS shall monitor the fan coil unit for status and raise alarms on system mismatch. The alarms raised shall be:

- space temperature <(10)ºC. or >(30)ºC.
- Any window open during out of hours occupancy.

Trend Logs

The BMS specialist shall set the following trends to be logged:

- space temperature
- outside air temperature
- Heating valve
- window command

These values shall be set for (10) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

2.3.19 Cycle Store Radiators

The MEP specialist shall provide radiators in the cycle store complete with thermostatic regulating valves.

The BMS specialist shall provide the 2 port modulating PICV isolation valves, and the heat meter that shall be connected to the BMS.

Heating Operation

The isolation valves shall be opened whenever the outside air temperature is <(15)ºC. which shall be user adjustable (± 5)ºC.

Trend Logs

The BMS specialist shall set the following trends to be logged:

- outside air temperature
- Heating valve

These values shall be set for (10) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

2.3.20 Heating and Cooling Systems

The low temperature hot water and chilled water is generated in the roof top 4 pipe air source heat pumps. The ASHPs are controlled, sequence and managed by the air source heat pump specialist supplied packaged control system.

Primary water for the heating cooling systems are circulated by variable volume pumps located in the basement. These pumps are controlled and managed by the ASHP specialist suppliers packaged control system. This management is via the BMS outstation monitoring outputs from the ASHP controller transmitting this via hardwired 4 to 20 mA signals to the basement panel where appropriate pumps and Pump speeds are selected.

Secondary chilled and heating water is circulated by duty/assist/standby variable speed pumps controlled and managed by the BMS. The pumps run at variable speed to maintain the system differential pressure set point.

The BMS shall have high-level and hardwired connections to the ASHP packaged control system through which the ASHP system demands the operation of the chilled and heating pumps and selects their speed. The BMS shall provide heating and cooling required signals to the ASHP controller and provide flow temperature setpoints.

The secondary pumps are enabled whenever the served area is in the heating or cooling demand as determined from the AHU valve positions and the AHU running in auto control.

The secondary pumps are also enabled for water quality circulation routines and through the use of the BMS software HOA switches.

The ASHPs are hardwired interlocked with isolating valves positions and pump proven operation, as well as internal safety interlocks.

The primary pumps operate as duty/assist/standby and duty rotate on a weekly basis or if in a fault mode. The secondary pumps operate as duty/standby and duty rotate on a weekly basis or if in a fault mode.

Each major plant item and distribution system is provided with heat meters which used for control strategy, energy monitoring and tenant billing.

The electrical services to the pumps are provided with MID approved electrical meters on a system by system basis and are used both for energy management and tenant billing.

The electrical power to the air source heat pumps is provided with MID approved electrical meters for energy management and tenant billing.

The pumps and air source heat pumps shall be provided with high-level interface for general status monitoring and system analysis.

Controls Hardware

The ASHP specialist shall provide, install and set to work the air source heat pump equipment and the associated control system.

The BMS specialist shall include costs for all interconnecting controls and network cabling between the packaged heat pump controller and each individual heat pump. This should include wiring the valve actuators and installation of all field sensors required by the ASHP specialist.

The BMS specialist shall separately provide immersion temperature sensors for ASHP leaving pipework from each machine and an ultrasonic heat meter for the individual heating and cooling outputs. The temperature sensors shall be wired to the BMS outstations and the heat meters to the BMS heat metering network.

The BMS specialist shall provide the 24V 2 position isolation valves as lift and lay type.

The ASHP specialist control panel shall be form 1 IP65 rated and constructed in 2 sections, one section being door interlocked with all LV controls requirements including MCBs and transformers. The other non-door interlocked section shall contain the ELV services and the DDC controller. The control panel shall include anti-condensation heating with a weather/rainproof enclosure provided by the ASHP specialist.

The BMS specialist shall provide a rooftop control panel 1 IP65 rated with a weather/rainproof enclosure provided by the BMS specialist and complete with anti-condensation heating. This control panel shall be hardwired to the ASHP panel through which demands for heating and cooling shall be sent along with the required flow temperatures. The panel shall monitor outputs from the ASHP control panel that shall indicate that primary chilled and heating water pumps are required to run and the speed at which the required to run.

These pump demands and speeds shall be transmitted via hardwired 4 to 20 mA signal from the rooftop panel to the basement heating and cooling control panels. In these panels the BMS strategy shall select the appropriate duty/standby pumps and the required speed.

The BMS specialist shall provide in the basement form 2B type 2 power boards for the circulating pumps and the pump inverters. The inverter shall be IP54 rated and mounted on frame alongside the pump sets. The BMS specialist shall provide all interconnecting controls and power wiring with late break early make isolators for the pump inverters between the control panels, the inverters and the drives.

The BMS specialist shall provide differential pressure sensors at the periphery of the secondary heating and cooling circulation systems that shall be used to vary the secondary pump speed to maintain the required differential pressure set point.

The BMS specialist shall provide the bypass valve at the top of each main riser which shall be modulated open if the pumps are running at minimum speed and differential pressure remains above set point.

The BMS specialist shall provide ultrasonic flow meters and matched temperature sensors for the primary and secondary circulating systems shall form part of the energy monitoring and system control strategy.

The plant status and plant HOA switches shall form part of a GUI displayed on an android style backlit colour display panel.

The BMS specialist shall provide all pump software interlocking that would include hardwired interlocks, pump software HOA switch and no existing pump alarm. If any of these are in a fault mode then the pump shall not be able to operate. Where software switches are provided if these are in the “HAND” mode then the pump shall be able to run assuming all hardwired interlocks are healthy. The system shall revert to auto after 4 hours, this time limit is only adjustable in software configuration mode.

The ASHP specialist shall provide all ASHP control strategy interlocking that would include hardwired interlocks from the safety panel, individual ASHP isolation valve proven open, ASHP software HOA switch and no existing ASHP alarm. If any of these are in a fault mode then the ASHP shall not be able to operate.

The BMS specialist shall provide for the secondary pump sequence control and system monitoring.

The ASHP specialist shall provide the air source heat pump thermal control and integral safety interlocking.

The pumps require a manual speed control when operating in a manual mode. This manual speed control limited to a minimum of 20 Hz shall be available to the user through a user adjustable GUI knob displayed on the BMS head end supervisor and at the pump control panel.

The major alarms when active shall illuminate the panel , alarm lamp. When the alarm reset button is operated ALL existing alarms within this local controller shall be cleared.

Each pump shall be user selectable at the BMS supervisor and the pump control panel to operate in the HOA mode by the BMS software switch.

Each pump set shall be provided with a duty/duty assist pump selection software switch that rotates the pumps in a cyclic manner through selection at the BMS supervisor or the pump control panel.

All modulating and isolation valves generally operate in auto mode. However, the BMS head end and pump Control Panel shall provide the user with manual override of these valves such that they can be permanently closed, open, in automatic mode at any fixed position. When the valves are in any mode other than automatic these shall be clearly indicated BMS head end supervisor graphic and the pump Control Panel display graphic

Operation - Secondary Heating System

The secondary heating system pumps that operate duty/standby shall be enabled whenever a heating demand is active, for stage 1 frost protection, water quality routine and if the pump HOA software switch is in the hand or auto mode. The pumps run at variable speed to maintain the system differential pressure set point duty rotate in fault and on a weekly basis.

BMS HOA Software

If the pump software switch is in the Hand mode the pump shall run assuming all hardwired interlocks are healthy for (4) hours and revert to auto.

Stage 1 Frost Protection

If the outside air temperature is at stage 1 frost protection, then the duty pump set is enabled. Stage 1 frost protection shall become active if the pump set is off and the outside air temperature is <(3)°C. The pump set shall run in normal pressure control with pump changeover as necessary.

Water Quality Routine

If the water quality routine is active the duty pump set shall be enabled and operate under normal pressure control with pump changeover as necessary. The water quality routine selection is held within the pump controller (CE-B-01B) and transmitted as a flag to all connected AHUs, UFH control panels, FCUs the remote duct re-heaters, trench heating and the system bypass valves. These remote control panels shall open fully the associated heating valve, unless the AHU is operating in normal mode or the control valve has been >(50)% open for >(1) hour in the previous (18) hours. The valve remains open until the water quality routine is disabled or the plant is required to operate normally. The water quality routine operates under a fixed time clock that is nominally set for (04.00)am for (1) hour on a daily basis. The calendar is fully adjustable at the BMS head end supervisor however, if the routine has not operated in the previous (72) hours a BMS alarm shall be raised. The water quality routine shall be held off if stage 1 frost protection is active.

Pump Interlocks

The hard wired primary pump interlocks shall include: not more than 2 pumps proven running, pressurisation unit low pressure healthy. The software interlocks shall include hardwired interlocks, no existing pump alarm, pump BMS HOA switch in either hand or auto mode.

The hard wired secondary pump interlocks shall include: not more than 1 pumps proven running, pressurisation unit low pressure healthy. The software interlocks shall include hardwired interlocks, no existing pump alarm, pump BMS HOA switch in either hand or auto mode.

Normal Operation

The system heating demand shall be determined based upon the served valves positions. If any served AHU heating valve is >(15)% open and in automatic control then the duty pump shall be enabled. The heating demand shall remain active until all served valves are closed for >(5) minutes. In this mode the heating demand shall be sent to the ASHP master control panel (CE-R-01).

When the system is required to operate the duty pump shall be enabled, assuming all interlocks are healthy, and the pump speed modulated to maintain the differential pressure set point at the least favoured sensor. If any field sensors is out of range, then it shall be removed from the control strategy.

The pump control differential pressure sensors shall have individual automatic adjustable set points, the nominal set point shall be (150)Kpa. The remote sensors set point shall automatically reset between limits (100 to 200)Kpa, to maintain at least one office AHU valve >(80)% open in that particular riser. Whenever the system starts the nominal set point shall be (150)Kpa, after (30) minutes of operation if all AHU valves in the particular riser are <(70)% open the set point shall be reduced by 10Kpa. If, however any valve on that riser is >(80)% open the set point shall be increased by (10)Kpa. This resetting shall continue at (30) minute intervals until the end of occupancy, if all valves on that particular riser remain <(70)% open then the set point continues to reduce, if any valve on the particular riser remains above (80)% open then the set point continues to increase. The resetting set point will only occur when the

heating system is operating at the design temperature nominally (45)ºC It should be noted that initially the flow temperature will be lower for the heating starting at a nominal (40)ºC

If the pump is running in the software HOA switch in hand mode, then the pump speed shall be the minimum set within the inverter. In this hand mode the pump speed can be modulated between (10 Hz to 50) HZ through a user selectable point on the BMS graphic and at the pump control panel.

If either the duty or assist pump fails to operate then the system rotates until that pump is in the standby position.

The duty pumps rotate on a weekly basis.

Sensor Faults

The control sensors shall be monitored and if out of range, then alternative sensors shall be utilised for the control strategy.

- If remote differential pressure sensor is out of range, then it is removed from the pump speed control strategy.
- If the outside air temperature sensor is out of range, then a temperature of 1ºC. shall be assumed.

System Alarms

The BMS shall monitor the system for status and raise alarms on system mismatch with a suitable grace time.

The critical alarms, that shall be indicated on the pump graphic and in the alarm list, illuminate the pump control panel fault lamp and be issued as an email shall be:

- Pump failing to run when commanded on.

The maintenance alarms, that shall be indicated on the pump graphic and when in the alarm list shall be:

- Differential pressure sensor out of range.
- Differential pressure >(20)Kpa below set point.
- Pump speed manually overridden.
- Pump in manual control.

Trend Logs

The BMS specialist shall set the following trends to be logged:

- Pump change of state - running/not running
- Pump speed BMS output
- Pump speed feedback from inverter
- Differential pressure set point(s)
- Differential pressure measured value(s)
- System flow and return temperature. (Dedicated temperature sensor)
- Energy meter LTHW entering water temperature - If INTEGRATED heat meter is used
- Energy meter LTHW leaving water temperature - if INTEGRATED heat meter issues

- Energy meter LTHW flow rate
- Instantaneous heat energy
- Accumulative heat energy.
- Instantaneous electrical energy for each pump.
- Accumulative electrical energy for each pump.

These values shall be set for (15) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

LTHW Pressurisation Unit and Water Treatment

The LTHW pressurisation unit and water treatment systems shall be powered from the BMS provided control panels and monitor the status by the BMS.

The pressurisation unit low pressure shall form part of the associated distribution pump set hardwired safety circuit.

The pressurisation unit common fault and high pressure switch shall be monitored the status.

System Alarms

The BMS shall monitor the system for status and raise alarms on system mismatch with a suitable grace time.

The maintenance alarms, that shall be indicated on the pump graphic and when in the alarm list shall be:

- LTHW pressurisation unit common fault including high pressure
- LTHW pressurisation unit low pressure
- LTHW separate pressure switch low-pressure
- Water treatment system fault(s).

Operation-Secondary chilled water cooling pump

The secondary CHW system pumps that operate duty/standby shall be enabled whenever a cooling demand is active, for stage 1 frost protection, water quality routine and if the pump HOA software switch is in the hand or auto mode. The pumps run at variable speed to maintain the system differential pressure set point duty rotate in fault and on a weekly basis.

BMS HOA Software

If the pump software switch is in the Hand mode the pump shall run assuming all hardwired interlocks are healthy for (4) hours and revert to auto.

Stage 1 Frost Protection

If the outside air temperature is at stage 1 frost protection, then the duty pump set is enabled. Stage 1 frost protection shall become active if the pump set is off and the outside air temperature is <(3)ºC. The pump set shall run in normal pressure control with pump changeover as necessary.

Water Quality Routine

If the water quality routine is active the duty pump set shall be enabled and operate under normal pressure control with pump changeover as necessary. The water quality routine selection is held within the pump controller (CE-B-01A) and transmitted as a flag to all connected AHUs, FCUs, trench cooling and the system bypass valves. These remote control panels shall open fully the associated heating valve, unless the AHU is operating in normal mode or the control valve has been >(50)% open for >(1) hour in the previous (18) hours. The valve remains open until the water quality routine is disabled or the plant is required to operate normally. The water quality routine operates under a fixed time clock that is nominally set for (03.00)am for (1) hour on a daily basis. The calendar is fully adjustable at the BMS head end supervisor however, if the routine has not operated in the previous (72) hours a BMS alarm shall be raised. The water quality routine shall be held off if stage 1 frost protection is active.

Pump Interlocks

The hard wired primary pump interlocks shall include: not more than 2 pumps proven running, pressurisation unit low pressure healthy. The software interlocks shall include hardwired interlocks, no existing pump alarm, pump BMS HOA switch in either hand or auto mode.

The hard wired secondary pump interlocks shall include: not more than 1 pumps proven running, pressurisation unit low pressure healthy. The software interlocks shall include hardwired interlocks, no existing pump alarm, pump BMS HOA switch in either hand or auto mode.

Normal Operation

The system heating demand shall be determined based upon the served valves positions. If any served AHU cooling valve is >(15)% open and in automatic control then the duty pump shall be enabled. The cooling demand shall remain active until all served valves are closed for >(5) minutes. In this mode the cooling demand shall be sent to the ASHP master control panel (CE-R-01).

When the system is required to operate the duty pump shall be enabled, assuming all interlocks are healthy, and the pump speed modulated to maintain the differential pressure set point at the least favoured sensor. If any field sensors is out of range, then it shall be removed from the control strategy.

The pump control differential pressure sensors shall have individual automatic adjustable set points, the nominal set point shall be (150)Kpa. The remote sensors set point shall automatically reset between limits (100 to 200)Kpa, to maintain at least one office AHU valve >(80)% open in that particular riser. Whenever the system starts the nominal set point shall be (150)Kpa, after (30) minutes of operation if all AHU valves in the particular riser are <(70)% open the set point shall be reduced by 10Kpa. If, however any valve on that riser is >(80)% open the set point shall be increased by (10)Kpa. This resetting shall continue at (30) minute intervals until the end of occupancy, if all valves on that particular riser remain <(70)% open then the set point continues to reduce, if any valve on the particular riser remains above (80)% open then the set point continues to increase. The resetting set point will only occur when the heating system is operating at the design temperature nominally (7)^{o}C It should be noted that initially the flow temperature will be higher for the cooling starting at a nominal (10)^{o}C

If the pump is running in the software HOA switch in hand mode, then the pump speed shall be the minimum set within the inverter. In this hand mode the pump speed can be modulated between (10 Hz to 50) HZ through a user selectable point on the BMS graphic and at the pump control panel.

If either the duty or assist pump fails to operate then the system rotates until that pump is in the standby position.

The duty pumps rotate on a weekly basis.

Sensor Faults

The control sensors shall be monitored and if out of range, then alternative sensors shall be utilised for the control strategy.

- If remote differential pressure sensor is out of range, then it is removed from the pump speed control strategy.
- If the outside air temperature sensor is out of range, then a temperature of 1°C. shall be assumed.

System Alarms

The BMS shall monitor the system for status and raise alarms on system mismatch with a suitable grace time.

The critical alarms, that shall be indicated on the pump graphic and in the alarm list, illuminate the pump control panel fault lamp and be issued as an email shall be:

- Pump failing to run when commanded on.

The maintenance alarms, that shall be indicated on the pump graphic and when in the alarm list shall be:

- Differential pressure sensor out of range.
- Differential pressure >(20)Kpa below set point.
- Pump speed manually overridden.
- Pump in manual control.

Trend Logs

The BMS specialist shall set the following trends to be logged:

- Pump change of state - running/not running
- Pump speed BMS output
- Pump speed feedback from inverter
- Differential pressure set point(s)
- Differential pressure measured value(s)
- System flow and return temperature. (Dedicated temperature sensor)
- Energy meter CHW entering water temperature - If INTEGRATED heat meter is used
- Energy meter CHW leaving water temperature - if INTEGRATED heat meter issues
- Energy meter CHW flow rate
- Instantaneous heat energy
- Accumulative heat energy.
- Instantaneous electrical energy for each pump.

- Accumulative electrical energy for each pump.

These values shall be set for (15) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

CHW Pressurisation Unit and Water Treatment

The CHW pressurisation unit and water treatment systems shall be powered from the BMS provided control panels and monitor the status by the BMS.

The pressurisation unit low pressure shall form part of the associated distribution pump set hardwired safety circuit.

The pressurisation unit common fault and high pressure switch shall be monitored the status.

System Alarms

The BMS shall monitor the system for status and raise alarms on system mismatch with a suitable grace time.

The maintenance alarms, that shall be indicated on the pump graphic and when in the alarm list shall be:

- Pressurisation unit common fault including high pressure
- Pressurisation unit low pressure
- Separate pressure switch low-pressure
- Water treatment system fault(s).

2.3.21 Air Source Heat Pump

The air source heat pumps are mounted on the roof to provide heating and cooling to the building. The air source heat pumps are provided with a specialist provided control package that shall manage the operation and sequence of the air source heat pumps and shall manage and request speed operation of the primary chilled and heating pumps.

The primary chilled and heating pumps are located in the basement and controlled and managed from BMS provided outstations. These outstations receive hardwired demands from the BMS rooftop outstation which in turn is hard wire connected to the ASHP controller. This controller transmits the requirement for pump operation and pump speed control.

Controls hardware

As described above in section 2.3.20

ASHP setting to work testing and commissioning

The air source heat pump specialist shall provide full technical details including software, wiring diagrams, off site software and panel testing of the air source heat pump control system. These shall be provided prior to delivery.

The ASHP specialist shall work in conjunction with the BMS specialist to develop the required interfaces both hardwired and software.

The ASHP specialist supplier shall set to work test and commission the complete system of their supply. The commissioning shall include full integration with the sitewide BMS and the ASHP specialist shall confirm, test and demonstrate to both the BMS specialist and later to the client full point to graphic (100% of all field and virtual points) between the ASHP system and the BMS head end dynamic graphics.

The ASHP specialist shall provide full attendance during the 7 day environmental testing and shall provide the handover system reports that demonstrate that the ASHP has performed as expected during this environmental test. These handover reports shall include all plant installation manuals, operating and maintenance manuals, hardware and soft copy of all software, panel wiring diagrams, system set points, system alarm set points.

The ASHP specialist shall provide 3 return visits at 3 month intervals following practical completion where they shall re-demonstrate the operation of the ASHP system during winter, spring/autumn and summer modes. During this testing the ASHP specialist shall re-confirm all field to graphic points, all user interfaces and all system management functions. These visits are technical soft landing types and are not to be seen as time spent correcting construction snags and defects.

ASHP operation

The air source heat pump specialist shall control and manage the ASHP's dependent upon demand from the sitewide BMS.

The sitewide BMS will call for heating

- if the secondary heating pumps are operating in a heating demand and the secondary flow temperature is >(2)ºC below required set point for (5) minutes. OR
- If the HWS is operating in a heating demand.

The sitewide BMS will call for cooling

- if the secondary chilled water pumps are operating a cooling demand and the secondary flow temperature is >(2)ºC. above the required set point for (5) minutes.

The heating demands shall be removed when the secondary heating pumps are not operating in a heating demand for >(10) minutes.

The heating demands shall be removed when the HWS is not operating in a heating demand for >(10) minutes.

The cooling demands shall be removed when the cooling system is not operating the cooling mode for >(10) minutes.

When the air source heat pumps have all been disabled in either the heating or the cooling mode then the isolation valves shall be opened to allow water circulation flush routine to be initiated.

Flow set points

The air source heat pumps have nominally been selected for it shall water temperature of 7°C to 12°C and a heating temperature of 40°C to 45°C.

The BMS shall reset the leaving water temperature setpoints such that the units run under lower load condition whenever possible. At start-up the chilled water temperature shall be set to a nominal 10°C

flow and the heating sent to a nominal 40° C flow. The heating temperature will be raised and the cooling temperature depressed to maintain if more than 1 AHU control valve is more than 80% open.

If temperature reset is not possible for the air source heat pumps, then the BMS shall consider the temperature resets only for the secondary circuits.

LTHW/HWS flow set point

The LTHW/HWS flow set point shall initially be set at (40)ºC this value shall be transmitted to the air source heat pumps and form the control set point for the LTHW/HWS secondary circuit. When the secondary circuit is operating in the HWS mode and if any calorifier HWS valve is >(80)% open for >(10) minutes, the LTHW set point shall be raised by (2)ºC If after a further (10) minutes any HWS valve is >(80)% open the LTHW temperature shall be raised to (45)ºC When this upper set point of 45°C is achieved the set point shall remain this value until the end of the occupancy period.

LTHW flow set point

The LTHW flow set point shall initially be set at (40)oC this value shall be transmitted to the air source heat pumps and form the control set point for the LTHW secondary circuit. When the secondary circuit is operating and if any AHU valve is >(80)% open for >(10) minutes, the LTHW set point shall be raised by (2)oC If after a further (10) minutes any AHU valve is >(80)% open the LTHW temperature shall be raised to (45)oC When this upper set point of 45°C is achieved in the set point shall remain this value until the end of the occupancy period.

CHW flow set point

The CHW flow set point shall initially be set at (10)ºC this value shall be transmitted to the air source heat pumps and form the control set point for the CHW secondary circuit. When the secondary circuit is operating in the cooling mode and if any AHU cooling valve is >(80)% open for >(10) minutes, the CHW set point shall be lowered by (2)ºC If after a further (20) minutes any CHW valve is >(80)% open the CHW temperature shall be lowered to (7)ºC When this lower set point of 7°C is achieved the set point shall remain this value until the end of the occupancy period.

Primary pump speed control

The primary heating pumps and primary cooling pumps are installed to provide duty assist and standby operation at a variable speed.

Although these pumps shall be managed by the BMS generally the required to operate and the speed required shall be determined by the ASHP control system. The BMS shall separately enable pumps for water quality routines and whenever the BMS software HOA switches are in the hand mode.

BMS HOA Software

Each pump shall be provided with a software HOA switch selectable through the graphics. If the pump software switch is in the Hand mode the pump shall run assuming all hardwired interlocks are healthy for (4) hours and revert to auto.

If the pump is running in the software HOA switch in hand mode, then the pump speed shall be the minimum set within the inverter. In this hand mode the pump speed can be modulated between (10 Hz to 50) HZ through a user selectable point on the BMS graphic and at the pump control panel.

Stage 2 frost protection

The duty pump runs for stage 2 frost protection and circulate water to the cooling system.

Water Quality Routine

If the heating or cooling water quality routine is active the duty pump set is enabled assuming all interlocks are healthy. The duty pump runs at a fixed speed, with duty rotation is necessary. The water quality routine operates under a fixed time clock that is nominally set for cooling (04.00)am for (1) hour on a daily basis and heating (05.00)am. The calendar is fully adjustable at the BMS head end supervisor however, if the routine has not operated in the previous (72) hours a BMS alarm shall be raised. The water quality routine shall be held off if stage 1 frost protection is active or if the system is running in normal control.

Pump Interlocks primary chilled water

The pump shall be hardwired interlocked such that no more than 2 pumps can run at the same time, the chilled water low pressure requires to be healthy. The software interlocks shall include hardwired interlocks and at least 1 air source heat pump cooling isolation valve proven open, no existing pump alarm, pump BMS HOA switch in hand or auto mode.

Pump Interlocks primary LTHW

The pump shall be hardwired interlocked such that no more than 2 pumps can run at the same time, the LTHW low pressure requires to be healthy. The software interlocks shall include hardwired interlocks and at least 1 air source heat pump heating isolation valve proven open, no existing pump alarm, pump BMS HOA switch in hand or auto mode.

Normal Operation

When the air source heat pump heating system is called to operate the BMS sends an appropriate demand to the ASHP control system. The ASHP control system selects the appropriate units to operate, having opened the unit isolation valve a demand is sent to the BMS to enable the appropriate heating or cooling pump.

The BMS selects the duty pump and enables this at the required speed. As load changes this is determined by the air source heat pump sensors which in turn by the control system open and close, enable and disable the air source heat pumps as required. During these operations, the ASHP control system shall transmit to the BMS required number of heating and cooling pumps necessary and the required speed.

The BMS selects the appropriate number of pumps and operates these at the required speed for controllers in the basement.

When a pump has failed to run when commanded the pumps shall be duty cycled such that this failed pump is now the standby and the other pumps are enabled as appropriate.

The pumps shall duty rotate on a weekly basis.

At the end of occupancy when heating demands and cooling demands have been removed the ASHP isolation valves shall be opened fully. This shall remain open until the next demand periods with the valve shall close and the duty ASHP valve reopened and the system started in normal sequence control.

The valves are opened to allow the primary circulating pumps to run for either frost protection, water treatment routines or manually if requested.

Sensor Faults

The control sensors shall be monitored and if out of range, then alternative sensors shall be utilised for the control strategy.

- If any secondary flow temperature sensor is out of range, then it shall be removed from the control strategy. The BMS shall call for the ASHP to run heating or cooling if the secondary system is in a heating or cooling demand the respective of the secondary flow temperature.

System Alarms

The BMS shall monitor the system for status and raise alarms on system mismatch with a suitable grace time.

The critical alarms, that shall be indicated on the system graphic and in the alarm list, illuminate the control panel fault lamp and be issued as an email shall be:

- ASHP fault major
- Pump failing to run when commanded on.
- Secondary LTHW flow temperature <(40)^{o}C. in a heating mode.
- CHW secondary temperature > (12)^{o}C. in a cooling mode.

The maintenance alarms, that shall be indicated on the pump graphic and when in the alarm list shall be:

- Pump in manual control
- Temperature sensor out of range
- Flow meter out of range.

Trend Logs

The BMS specialist shall set the following trends to be logged:

- ASHP entering and leaving heating and cooling water temperatures.
- ASHP running heating and/or cooling mode.
- Common heating flow temperature.
- Common heating return temperature.
- Common heating flow rate.
- Secondary heating flow temperature
- Secondary heating return temperature.
- Secondary heating flow rate
- Common CHW flow temperature.
- Common CHW return temperature.
- Common CHW flow rate.
- Secondary CHW flow temperature

- Secondary CHW return temperature.
- Secondary CHW flow rate
- Flow rate from each ASHP.
- Instantaneous heat & coolth energy for each ASHP
- Accumulative heat & coolth energy for each ASHP.
- Instantaneous electrical energy for each air source heat pump.
- Accumulative electrical energy for each ASHP.
- Number of primary heating pumps required (from ASHP controller)
- speed of primary heating pumps required.
- Number of primary cooling pumps required (from ASHP controller)
- speed of primary cooling pumps required

These values shall be set for (15) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

2.3.22 Potable Domestic Cold Water Systems

The domestic cold water system storage tanks located in the basement distribute wholesome water via packaged cold water booster sets. Incoming water from the mains is provided with major water leak detection systems and motorised isolation valves all of which shall be monitored by the sitewide BMS.

Controls Hardware

The MEP specialist shall provide a domestic booster set and storage tank in the basement plant room space. The booster set shall be provided with integral controls and the tank with a Tanktronic type unit.

The wholesome booster set, and storage tank and local water treatment systems shall be provided with control sensors and monitoring by the BMS specialist. The BMS specialist shall provide immersion temperature sensors for both sections of the tanks and ultrasonic level meters that shall be used to calculate the stored volume.

The BMS specialist shall provide a form 2B type 2 mechanical services power boards and form 1 control panel for the public health services in the tank room.

The BMS specialist shall provide all controls interlocking cabling between the potable Tanktronic unit, the tank level switches the MEP provided solenoid valves and the booster set. The booster set shall be disabled through hardwired interlocks on low water level in the storage tanks and the isolation valve close alarm.

The systems shall be monitored by the BMS supplied DDC controller that communicates to the sitewide BMS via the converged network utilising BACnet/IP. The controller is held within a non-door interlocked section of the control panels and is provided with a backlit colour display mounted on the fascia of the panel.

The MEP specialist shall provide WRAS approved water meters and the major water leak detection system. The water meters shall be provided with M-bus connectivity by the BMS specialist which shall be connected to the sitewide BMS/EMS forming part of the energy monitoring and billing system.

The BMS specialist shall provide pulse splitters for the authority water meters with 1 output available for the local authority and the other connected to a BMS provided M-bus pulse counter.

System Operation

The potable booster set shall be available for operation continuously however these shall be hardwired interlocked with low-level switches in both section of the tank to prevent dry operation of the booster set.

The potable mains water solenoid valves shall be closed through hardwired interlocks if the Tanktronic high level alarm is active.

The water treatment systems shall be provided integral control and operate continuously.

System Alarms

The BMS shall monitor the system for status and raise alarms on system mismatch with a suitable grace time. The critical alarms, that shall be indicated on the domestic water graphic and in the alarm list, illuminate the pump control panel fault lamp and be issued as an email shall be:

- Major water leak detection
- Potable Tank low level
- Potable tank high level alarm

The maintenance alarms, that shall be indicated on the system graphic and when in the alarm list shall be:

- Booster set fault
- Tank temperature >(25)^{o}C
- Tanktronic unit alarm.
- Water treatment alarms

2.3.23 Non Potable Domestic Cold Water Systems

The non potable domestic cold water system storage tanks located in the basement and distributed via packaged cold water booster sets.

The MEP specialist shall provide a non potable domestic booster set and storage tank in the basement plant room space. The booster set shall be provided with integral controls and interlocked to low level switches through the BMS control panel.

The booster panel is powered from the BMS provided mechanical services power board complete with all internal pressure control and safety interlocks.

System Alarms

The BMS shall monitor the system for status and raise alarms on system mismatch with a suitable grace time. The critical alarms, that shall be indicated on the domestic water graphic and in the alarm list, illuminate the pump control panel fault lamp and be issued as an email shall be:

- Non potable Tank low level
- Non potable tank high level alarm

The maintenance alarms, that shall be indicated on the pump graphic and when in the alarm list shall be:

- Booster set fault

2.3.24 Water Meters

The MEP specialist shall provide local authority approved water meters at the locations described on the public health specifications and schematics. These meters shall be provided complete with a M-Bus collectors that shall be connected to a BMS water metering network by the BMS specialist.

The utility water meter shall be monitored and billed by the utility supply. The BMS specialist shall provide pulse splitters for the utility metering systems/major water leak detection units. The pulsed out puts shall be split and the BMS monitor one set of contacts.

The future tenant on each floor plate shall provide a water meter for connection to the sitewide BMS/EMS monitoring system. This meter shall be complete with M-bus conductivity. The BMS specialist shall provide temporary domestic water meters with a M-Bus interface and a metering network for the tenants from the ground floor to level 11 office. The meters that shall be WRAS approved are a temporary measure by which the BMS shall be configured and tested to demonstrate water metering capability.

The BMS specialist shall provide the M-bus network which shall rise up both tenant risers and at each floor should be provided with a junction box complete with terminal rails for the termination and the continuation of the M-Bus network. The tenant shall use these junction boxes to connect future meters and shall in turn employ the landlords BMS specialist to configure these new meters to the tenant billing and monitoring system.

The BMS specialist shall provide billing software as part of the Basebuild works that will accommodate these future water meters however, set up for configuration will only take place when the tenants are in situ.

2.3.25 Domestic Hot Water Systems

The HWS is generated by two water source heat pumps located in the basement taking energy from the LTHW system primary pipe. Each calorifier is provided with a separate WSHP and a set of run and standby constant volume pumps.

The primary side WSHP pumps are variable volume and operate whenever the WSHP is required to operate.

Each calorifier is provided with a local plate heat exchanger and a 4 port valve controlled and managed by the calorifiers package control system.

Domestic hot water is circulated to the users via pressure from the cold water booster system with a local pump circulation to maintain water temperatures.

The system runs to a fixed time clock and is provided with the pasteurisation cycle.

Within the calorifiers immersion heaters are provided that shall include thermostat and high temperature cut out. These shall be wired to the BMS control panels and used only when the water source heat pump is unavailable.

Controls Hardware

The MEP specialist shall provide the water source heat pump complete with all thermal controls and safety interlocks. The BMS specialist shall provide power to the unit from the BMS power board and include all interconnecting controls cabling both to the BMS control panel and required for the water source heat pump local control.

The MEP specialist shall provide the water source heat pump with ELV connections for control and monitoring and a high-level interface for general monitoring.

The MEP specialist shall provide the primary and secondary side circulating pumps that shall be controlled and managed by the sitewide BMS. The BMS specialist shall include inverters although, pumps with integral inverters and speed control are preferred.

The MEP specialist shall provide pressurisation units for each individual LTHW circuit complete with integral controls. The BMS shall monitor low pressure interlock this with the pump commands in the operation of the water source heat pump.

The MEP specialist shall provide the calorifier with integral controls and safety interlocks. The 4 port modulating valve shall be complete with a potentiometer output to define the position of the valve that shall be monitored by the sitewide BMS. This valve position shall be used by the BMS to enable/disable the LTHW heating circuit.

The MEP specialist shall provide the HWS circulation pump with integral speed control and ELV terminals that shall be wired to the BMS.

The BMS specialist shall provide contactors and soft start for the immersion heaters. The contactor and soft start shall be within the BMS provided power board that shall be hardwired interlocked with the immersion stat and the integral high temperature cut out. The contactor shall be enabled by the BMS if HWS is required and the WSHP is not available.

System Operation

The HWS calorifiers and shall be enabled to a fixed time clock, whenever the basement ventilation system is active, and to provide pasteurisation. The system shall also run to a BMS system software HOA switch when it shall operate for (4) hours with normal thermal control. The pump sets shall have individual BMS HOA switches for manual selection when the pumps run at the minimum speed held within the inverter and manually adjustable value through the BMS supervisor and the pump control display panel.

BMS HOA Software

If the pump software switch is in the Hand mode the pump shall run assuming all hardwired interlocks are healthy for (4) hours and revert to auto.

If the calorifier shunt pump software switch is in the Hand mode the pump shall run assuming all hardwired interlocks are healthy for (4) hours and revert to auto.

If the system BMS HOA switch is in the Hand mode the system shall run with normal thermal control shall run assuming all hardwired interlocks are healthy for (4) hours and revert to auto.

Water Quality Routine

If the water quality routine is active the LTHW and LTHW/HWS pump set is enabled and operates under normal control with pump changeover, as necessary.

The water quality routine operate under a fixed time clock that is nominally set for (04.00)am for (1) hour on a daily basis. The calendar is fully adjustable at the BMS head end supervisor however, if the routine has not operated in the previous (72) hours a BMS alarm shall be raised. The water quality routine shall be held off if pasteurisation or normal HWS control is active. During this mode the water source heat pump shall not be enabled but both isolation valve shall be driven open.

Pasteurisation Cycle

The system is enabled once per day for the pasteurisation cycle. The system runs until the temperature measured at both the HWS flow and return sensors is >(60)ºC for >(60) minutes.

The operational time of the pasteurisation cycle is user adjustable but should nominally be set to daily from (04.00)am.

If the roof top air source heat pumps are not operating when pasteurisation is required then the BMS shall enable the electric immersion stats to achieve heating within the HWS system.

Normal Operation

When HWS is required both calorifiers and both associated water source heat pumps shall be made ready to operate.

The BMS shall monitor the HWS 4 port control valve and when this valve is more than (80)% open the appropriate heating circuit shall be enabled. The circuits shall remain enabled until the valve is <(10)% open.

The system shall also be enabled if HWS is required and the distribution flow temperature is <(55)ºC. And disabled when the distribution flow temperature is >(61)ºC.[1] this strategy shall override the valve position strategy.

When an individual calorifier is required to operate the duty HWS/LTHW pump shall be enabled, assuming interlocks are healthy, and the WSHP primary side heating valve opened and a heating demand sent to the central plant. The central plant only start this demand between the hours of (07.00 to 21.00) outside of these hours the BMS shall enable the calorifiers immersion heaters to achieve set point. This however shall not occur if the ASHP are already running from some other demand.

The appropriate duty LTHW/HWS pump shall be enabled with duty change over in a fault and a fixed time mode.

The primary side LTHW duty pump shall be enabled at variable speed (50% and 100%) based upon the number of WSHP isolation valves open.

The pump hardwired interlocks shall include: system low pressure healthy, (for the primary side pump) at least one WSHP isolation valve proven open. The software interlock shall include hardwired interlocks, no existing pump alarm, BMS pump software HOA switch in hand or auto. If in hand the pump shall run for 4 hours and then revert to auto.

The water source heat pump shall be enabled when all interlocks are healthy these shall include: HWS/LTHW circulation pump proven running, inlet heating isolation valve proven open, high temperature

[1] The 61° flow temperature turnoff needs to be approximately 2° C below the HWS package controller set point.

cut out healthy and primary LTHW pump operating. The software interlock shall include hardwired interlocks, no existing WSHP alarms, WSHP BMS OA switch in auto (no hand position required).

Whenever a WSHP is disabled the primary side heating valve shall be closed and the primary side pump speed reduced.

Whenever an WSHP is enabled and it shall run for a minimum of (15) minutes and a minimum of (5) minutes of time.

When HWS is not required the heat pumps shall be disabled, the circulation pumps shall continue to operate for (5) minutes and then shut down. The WSHP isolation valve shall be opened to allow water quality routines in general pump operation outside normal condition.

If the LTHW or the LTHW/HWS water pump is running in the software HOA switch in hand mode then the pump speed shall be the minimum set within the inverter. In this hand mode the pump speed can be modulated between (10 Hz to 50) HZ through a user selectable point on the BMS graphic and at the pump control panel.

If the duty pump fails to operate then the system carries out a duty rotation such that the failed duty pump is now in the standby position.

The duty pumps rotate on a weekly basis.

Each isolation valve shall be opened and closed once per day in a continuous cycle at (01.00).

System Alarms

The BMS shall monitor the system for status and raise alarms on system mismatch with a suitable grace time.

The critical alarms, that shall be indicated on the system graphic and in the alarm list, illuminate the control panel fault lamp and be issued as an email shall be:

- Pump failing to run when commanded on.
- WSHP fault
- HWS high temperature cut out active.

The maintenance alarms, that shall be indicated on the pump graphic and when in the alarm list shall be:

- Pump speed manually overridden.
- Pump in manual control
- isolation valve failed to open.
- Temperature sensor out of range

Trend Logs

The BMS specialist shall set the following trends to be logged:

- Pump change of state - running/not running
- Pump speed feedback from inverter
- WSHP change of state - running not running
- LTHW-WSHP entry water temperature.

- LTHW-HWS return water temperature.
- Calorifiers temperature sensor measured values.
- Calorifiers 4 port valve position.
- HWS flow and return temperature.
- Energy meter LTHW entering water temperature - If integrated heat meter is used
- Energy meter LTHW leaving water temperature - if integrated heat meter is used
- Energy meter LTHW flow rate
- Instantaneous heat energy
- Accumulative heat energy.

These values shall be set for (15) minute intervals however, the user shall be to adjust these to any reasonable value as a minimum 30 seconds for investigative maintenance routines.

HWS/LTHW Pressurisation Unit and Water Treatment

The LTHW/HWS pressurisation unit and water treatment systems shall be powered from the BMS provided control panels and monitor the status by the BMS.

The pressurisation unit low pressure shall be healthy before the associated pump sets can run.

System Alarms

The BMS shall monitor the system for status and raise alarms on system mismatch with a suitable grace time. The maintenance alarms, that shall be indicated on the pump graphic and when in the alarm list shall be:

- LTHW pressurisation unit common fault including high pressure
- LTHW pressurisation unit low pressure
- LTHW separate pressure switch low-pressure
- Water treatment system fault(s).

2.3.26 Grey and Rainwater Systems

The grey and rainwater systems shall be supplied complete as packaged units and powered from local BMS provided power boards. The systems shall have integral controls by the specialist and are monitored the status by the sitewide BMS.

The BMS specialist shall provide power to the control panels and booster sets from the BMS provided mechanical services power board.

The MEP specialist shall provide all interconnecting controls wiring power wiring and system control instruments and actuators and set the complete system to work.

2.3.27 Trace Heating and Heat Maintenance Tape

The MEP specialist shall provide trace heating and where necessary heat maintenance tape complete with necessary thermostats and controllers. Within the basement power shall be provided from the MSPBs whilst on the floors these shall be from the local distribution board. The BMS shall monitor fault status of the systems.

2.3.28 Sump Pumps

The MEP specialist shall provide sump pumps with appropriate control panels, water level switches and all interconnecting power and controls cabling.

The BMS specialist shall provide power to the sump's pump from the local BMS provided mechanical service power board and shall monitor the sump pumps for fault and power available. The BMS specialist shall provide an interposing relay within the sump pump panel wired in series with the general sump pump alarm downstream of the panel isolator to confirm power available.

The firefighting sump pump SP 3 requires separate high level monitoring by the BMS that shall be hardwired interlocked with the MEP provided, water isolation valve serving the shower area. The valve that shall be normally closed is only allowed to open when the water tank level is below the high level switch.

2.3.29 Sprinkler System

The MEP shall provide and set to work the life safety sprinkler system. Generally, the system shall be monitored by the fire alarm system however, the BMS specialist shall separately provide level switches for the storage tank monitor these on the BMS raising high and low level alarms as appropriate.

2.3.30 Electrical Meter Services

The electrical meters in the MCCs, mechanical services power boards, switchboards and the distribution boards shall be provided with Modbus output. These shall be connected to the BMS and form part of the energy monitoring system.

The BMS specialist shall provide a Modbus network and Modbus/BACnet Gateway.

The BMS/EMS system shall read the meters at 15 minute intervals and maintain historical data for 13 months. The meter readings and historical data shall be displayed as requested at the BMS supervisor and shall form part of the tenant billing system.

2.3.31 Electrical Services Monitoring

The switchboards shall be provided with tripping batteries surge arrestors and motorised breakers as appropriate. The BMS shall monitor the status of the major breakers, surge arrestor and tripping batteries and display these as dynamic points on the BMS head end supervisor.

The BMS shall monitor the life safety UPS system and raise alarms as appropriate.

System alarms

The BMS shall monitor the electrical services for status and raise alarms on system mismatch. The alarm is raised shall be:

- tripping battery fault.
- Surge arrestor fault.
- UPS alarm.

2.4 ATS Monitoring

The electrical specialist shall provide ATS units as described in the electrical specification complete with Modbus connectivity. The BMS specialist shall connect the Modbus to the BMS for monitoring an alarming on change of state.

2.5 Energy Metering

The BMS specialist and others shall provide energy meters for the project that should include: heat meters, electrical meters, water meters. All meters shall be MID approved

The heat meters shall be BACnet MSTP, the electrical meters shall be Modbus and the water meters shall have M-bus connectivity. These meters that shall be positioned in switchboards, distribution boards, mechanical services power boards, heating cooling systems, water distribution systems shall be wired together by the BMS specialist to form an energy metering network.

The instantaneous and historical energy that shall be recorded at 15 minute intervals shall form part of the energy monitoring system and the tenant billing systems.

The electrical meters shall be provided by the electrical specialist within little distribution board and BMS specialist within BMS provided panels. These meters shall be MID approved and networked by the BMS specialist to the BMS/EMS metering system.

The water meters shall be provided by the specialist supplier with an-M-bus communication modules that shall be networked by the BMS specialist to the BMS/EMS metering system.

Energy meters shall be displayed graphically as a ladder diagram the sitewide services and individually on graphics for specific plant.

2.5.1 Energy Monitoring

The BMS specialist shall provide and set to work the energy monitoring system. This shall be integrated with the site wide automatic control system and include all necessary interface gateways networks, firmware, software and storage systems.

The site wide automatic control system shall include an energy monitoring feature and reporting generally in line with TM 39.

All electrical meters within the main distribution switch board and the on floor distribution boards shall be provided with Modbus output and networked together to the energy management system.

The MCCs and mechanical services power boards shall have electrical meters for the water source heat pumps, the AHUs, the circulation pumps, the ventilation plant, and the domestic water systems. These meters shall be provided with Modbus output and networked together to the energy management system.

The instantaneous and historical power for each meter shall be displayed on the site wide BMS display screen when requested by the user.

The meters shall be read at 15 minute intervals with sufficient storage capacity provided within the energy monitoring system for up to 13 months data to be retained and reviewed for all connected meters.

The energy displays shall be displayed on the associated plant graphic and separately on dashboards and schematics that can be laid out similar to LV schematic drawing.

Lighting & small power

The energy associated with lighting and small power is directly measured at the distribution board meter as a common value.

On floor Air handling plant & fan tiles

The on floor air handling plant and the fan tiles are powered from the mechanical services power board. The power boards shall be complete with MID approved electrical meters that shall be networked to the BMS/EMS and form part of the energy monitoring and tenant billing system.

The on floor air handling plants which generally 2 per tenant shall be provided with MID approved heat meters for the heating cooling systems for the individual tenants, not individual AHUs. These meters shall be connected to the BMS/EMS heat metering network and form part of the energy monitoring and tenant billing system.

The BMS specialist shall provide monitoring of the AHU EC motor by direct connection to the Modbus output from the variable speed drive. Although the readings are not sufficient for tenant billing they shall be recorded as part of the energy monitoring system.

These meters shall be recorded at 15 minute intervals.

The energy consumed by the AHU fan shall be derived from the variable speed drive output, alternatively a fixed value shall be assumed based upon 90% of the motor nameplate. This latter alternative shall only be used if the Modbus is not connected.

The power consumed by the fan tiles, that contain electric heaters, shall be assumed to be a fixed value based upon 90% of the motor nameplate.

The power consumed by the electric heaters shall be the difference between the fan tiles and the AHU and the value measured in the mechanical services power board.

Fresh air Air handling plant

The office fresh air air handling plants are provided as package units power feeds to the fans, electric heaters, air source heat pumps and other associated AHU equipment.

The power to the AHU control panel is provided from the BMS specialist panel complete with MID electrical meter that shall be monitored by the BMS as part of the energy monitoring and tenant billing system.

The fans are EC motors shall be provided with Modbus output by the AHU specialist wired directly to the AHU control panel. Alternatively, and to be priced by the BMS specialist these EC motor speed drive shall be connected to the BMS via the Modbus connection.

The power consumed by the ventilation fans shall be measured directly from the EC motor output.

The electrical power consumed in a heating/cooling mode shall be determined from the total power delivered to the AHU measured at the BMS MID electrical meter, less that used by the fan. To apportion heating and cooling to this final electrical value it may be assumed that heating is required when the outside air temperature is <(17)ºC. and that cooling is required above this value.

Basement Air handling plant

The basement air handling plant is provided as a package units with power feeds to the fans, electric heaters, air source heat pumps and other associated AHU equipment.

The power to the AHU control panel is provided from the BMS specialist panel complete with MID electrical meter that shall be monitored by the BMS as part of the energy monitoring and tenant billing system.

The fans have EC motors that shall be provided with Modbus output by the AHU specialist wired directly to the AHU control panel.

The power consumed by the ventilation fans shall be measured directly from the EC motor output.

The electrical power consumed in a heating/cooling mode shall be determined from the total power delivered to the AHU measured at the BMS MID electrical meter, less that used by the fan. To apportion heating and cooling to this final electrical value it may be assumed that heating is required when the outside air temperature is <(17)^{o}C. and that cooling is required above this value.

Toilet Ventilation Air handling plant

The toilet air handling plant is provided as a package units with power feeds to the fans, electric heaters, air source heat pumps and other associated AHU equipment.

The power to the AHU control panel is provided from the BMS specialist panel complete with MID electrical meter that shall be monitored by the BMS as part of the energy monitoring and tenant billing system.

The fans are EC motors shall be provided with Modbus output by the AHU specialist wired directly to the AHU control panel.

The power consumed by the ventilation fans shall be measured directly from the EC motor output.

The electrical power consumed in a heating/cooling mode shall be determined from the total power delivered to the AHU measured at the BMS MID electrical meter, less that used by the fan. To apportion heating and cooling to this final electrical value it may be assumed that heating is required when the outside air temperature is <(17)^{o}C. and that cooling is required above this value.

Level 12 floor fresh air ventilation Air handling plant

The 12th floor air handling plant is provided as a package units with power feeds to the fans, air source heat pumps and other associated AHU equipment.

The power to the AHU control panel is provided from the BMS specialist panel complete with MID electrical meter that shall be monitored by the BMS as part of the energy monitoring and tenant billing system.

The fans are EC motors shall be provided with Modbus output by the AHU specialist wired directly to the AHU control panel. Alternatively, and to be priced by the BMS specialist these EC motor speed drive shall be connected to the BMS via the Modbus connection.

The power consumed by the ventilation fans shall be measured directly from the EC motor output.

The electrical power consumed in a heating/cooling mode shall be determined from the total power delivered to the AHU measured at the BMS MID electrical meter, less that used by the fan. To apportion heating and cooling to this final electrical value it may be assumed that heating is required when the outside air temperature is <(17)ºC. and that cooling is required above this value.

Bin store Ventilation

The bin store is provided with ventilation from the MVHR and associated electric heater battery. The MVHR fan power may be assumed to be 90% of the motor nameplate and the heating element shall be provided with an MID meter in the BMS panel that shall be connected to the BMS/EMS monitoring system

Ventilation smoke fan basement

The basement ventilation fans are provided with inverters that have Kilowatt-hour meters as part of the integral software. These values shall be read at half hour intervals by the BMS stored in the database These values shall form part of the TM 39 electrical monitoring for ventilation systems.

Fan coil units

The mezzanine level fan coil units are powered from the mechanical services power board that should be complete with a MID electrical meter monitored by the BMS/EMS.

The heating and cooling distribution circuits are provided with approved heat meters that shall form part of the power monitoring system.

LV room cooling & BOH heating/cooling system

The LV room and the back of house areas are provided with heating and cooling from roof top mounted air source heat pumps.

The power to the air source heat pumps are provided from the rooftop BMS mechanical services power boards with MID approved electrical meters.

It may be assumed that heating is required at outside air temperatures below 12°C.

Domestic water systems

The domestic water systems (potable and nonportable booster sets, irrigation system, sump pumps and attenuation tanks) are fed from a MCC complete with an electrical meter dedicated to these services. The 15 minute meter reading shall be assigned to domestic water systems.

Domestic hot water services

The air source heat pumps and the immersion heaters associated with the HWS system are served from a BMS provided power board that has electrical meters for the air source heat pumps and separately for the immersion heaters and the circulation pumps.

The 15 minute meter reading shall be assigned to the domestic hot water system.

2.5.2 Energy management and billing package

The BMS specialist shall provide and set to work the energy management and tenant billing system. The systems shall be developed to provide both tenant billing and energy monitoring.

Tenant bill

The BMS specialist shall provide and configure a standard tenant billing package that may require modification to suit this particular site.

The tenant billing package that shall be for the individual office demise and shall be generated automatically when requested by the user.

The bill shall include for each tenant such information as:

- Meter references
- The tenant's name;
- The tenant's account number;
- The tenant's address.

The bill shall include for each type of meter such information as:

- The previous energy meter reading and date -separate data shall be provided for low tariff/high tariff times;
- The current energy meter reading and date - separate data shall be provided for low tariff/high tariff times;
- The energy use in the billing period - separate data shall be provided for low tariff/high tariff times;
- The client charge for energy unit rate;
- The total charge for the energy;
- Client add-on service charges;
- VAT;
- The energy used in the previous year.

The billing system shall include the ability to include central support services as well as the directly measured meters.

Display and billing data

The BMS specialist shall develop the system to provide both graphical and meter tree views of:

- Landlords main electrical and associated distribution to MCC's, MSPB and associated VSD's (via BACnet high level Interfaces), EC motors (via Modbus interface) to show the energy distribution usage and power / demand Usage together.
- Tenants' electrical usage of lighting combined with small power, on floor AHU including fan's and heating/cooling meters. This shall show the energy distribution usage and power / demand usage metering and ability for tenants to view the daily, weekly and monthly energy usage profiles and bar Charts via the WEB or any Tablet device.
- Landlords & Tenants LV Power Meter Monitoring to display: phases, power factors, neutral currents & distributed building loads.
- Landlord and tenants heat metering to display: entering and leaving water temperatures, flow rates, instantaneous and accumulative energy consumption.

- Building energy dashboards of main utility and building daily, weekly, monthly energy profile of domestic water, heating and cooling and electricity usage and consumption of the building and its systems split into Landlords / Tenants usage.
- Automatic monthly reading and emailed output in CSV spreadsheet in an agreed format to allow the Building and Energy Managers to manipulate data as required.

Incoming Services

For the incoming services, the BMS Specialist shall include for but not be limited to the following:

- Monitoring and logging the kWh consumption of each of the main LV switch feeds via multifunction Modbus meters.
- Monitoring and logging of mains cold utility and all sub-meters via M-bus.

Metering

Energy metering is to be provided to meet the requirements of Part L of the Building Regulations and CIBSE's guide TM:39 requiring that all "Sub-metering should enable at least 90% of the estimated annual energy consumption of each fuel to be allocated to specific energy end uses, i.e., what it is used for rather than where in the building it is used."

The BEMS shall enable the 'Energy Manager' to understand and monitor where energy is used throughout the building. Within the office floor areas the following sub-meters shall be provided to cover the energy supply to all tenanted areas:

- Floor small power, lighting and mechanical services.
- Tenant portion of office AHU heating, cooling and ventilation load.
- Floor water meters (future).

Specific Metering & Billing Requirements

The BMS specialist shall undertake the following Metering and Billing package works in accordance with all drawings, and schedules as described within this specification and as follows:

- Supply, install a 19" rack mounted server into the building services cabinet together with a client PC with Ultra-Wide 23" HD Screen
- Supply, design, setup & configuration of a fully HTML5 Compliant On-Prem WEB deployed metering and billing system together with ability to provide automatic Monitoring & Targeting, Energy, Environmental, Benchmarking and Targeting of all Landlords buildings, Water & Electrical systems including Tenants Floor / Zone Demand usage profiles.
- Configuration of all Meter data logging Data Collectors to provide at least 30 days of meter data backup in the event of EMS Server failure.
- The Metering & Billing System shall read the logged data directly from the data collectors via an Open protocol such as oBIX (Open Building Information Exchange) and not directly from the meter. In the event of any Network Backbone or Metering & Billing Software or Server issues, the Metering and Billing software shall reconnect and re-read any stored History data from the previously last know Half Hourly time stamp and fill-in any missing data.

- Setup and configuration of Mains Utility Check Meters and display on Metering & Billing System Meter Trees.

The BMS specialist shall setup and provide configuration of all LV Switchboard, distribution board and mechanical service power board, MCC, Metering via Multifunction Meters for Meter Tree, Floor, Topology and Schematic Graphics display, data manipulation and reporting on Metering & Billing System.

The electrical metering provider

- (electrical specialist for distribution boards and switchgear)
- BMS specialist for mechanical services power boards and MCCs
- specialist equipment suppliers

shall provide all MID electrical meters and undertake the following:

- Check calculation of LV and DB's to MCC's Input Supply Meters, the difference (Losses), shall be added to the associated Floor/Zone Tenants Bills
- Check calculation of Landlords LV Switchboard outgoing supplies serving Lifts and directly apportioning these costs to Tenants Bills
- Check calculation of Landlords LV Switchboard Input Supply meter with all outgoing Check Meters, the difference (Losses) shall be directly apportioned to Tenants Bills
- Check calculation of Landlords LV Switchboard with all Tenants Busbar Riser Outgoing Check Meters and also checked against the accumulated Tenants Busbar Meters, the difference (Losses) shall be directly apportioned to Tenants Bills
- Check Calculation of Utility Supplies with LV Switchboard Incoming Supplies including any transmission HV to LV Transmission Losses which are to be apportioned to across the Landlords / Tenants Bills.

The energy monitoring system shall record 15 minute, Daily, Weekly & Yearly summation of all LV Switchboard Incoming Multifunction Energy Meter Usage rolled up to the Total Utility Incoming Power Usage in the same Half Hour Period.

The BMS specialist shall setup and provide configuration of Water, heat meters, Electricity Meter Trees providing user access to individual meters and ability to drill into daily, weekly, monthly & yearly data logs together with Meter Tree summations and User adjustments and views of associated accumulated Switchboard Power Usage alarm limits.

The Metering system shall monitor the Tenants Time Clock Schedule, the Metering & Billing System shall undertake calculations of both "Core" and "Out Of Hours" usage together. During "Out Of Hours", only those Tenants in Occupation shall be Invoiced for their direct Floor / Zone energy usage and associated Ventilation, plant together with apportioned energy usage costs for Common Area Lifts, Escalators, Lighting and HVAC.

The Tenants shall be provided with WEB access via a VPN Firewall to their respective Floor / Zone Metering Billing and Metering Data and be able to undertake their own WEB Based data analysis, benchmarking and reporting.

The BMS specialist shall setup all Standard Landlords Water, heating/cooling meters, Electricity Meter aM&T analysis, Benchmarking, Alarming Reports together with User definable WEB based reporting templates.

Automatic Bill Generation and Energy Consolidation

The process of Tenant Bill generation shall be fully automated at the beginning of each month, the Metering and Billing package shall be configured to automatically produce Tenant Bills for each Tenanted Floor / Zone consolidated with the Total Building Electrical Half Hourly Utility together with Water Utility consumption, heating and cooling consumption, power transmission losses and associated costs in the same period. These costs shall be consolidated back to the Tenants re-charges plus any consumption in Landlords Common areas which shall be apportioned as follows:

- All Landlords Main HVAC Plant including Toilets and basement ventilation as derived from the MCC/MSPB Meters. This shall include electrical power consumed by the AHUs along with heating and cooling power directly consumed
- All landlords heating and cooling plant and associated circulating pumps power consumed shall be proportioned to the individual tenants relative to the heating and cooling energy that each tenant has absorbed from the central plant.
- Landlords Systems serving Common Area's including Lifts, and Lighting, Toilets and Air Conditioning. This shall be apportioned relative to the Tenants hours of occupancy.
- All landlords' electrical costs associated with the domestic hot water system apportioned relative to the tenants hours of occupancy.

Metering & Billing Checking & Data Analysis Requirements

The BMS specialist shall setup the Metering & Billing system to provide the following fundamental analysis and checking functionality:

- Invoice Validation, the Landlord shall have the ability to enter the respective Invoiced Water, heating/cooling consumption & Electricity consumption data, unit rate and be able to compare with the Metering & Billing system total consumption usage for the same monthly period including any tolerance checks to highlight where bills may be in error or where usage or cost varies significantly on any past performance
- The ability to recharge individual tenants based on the Building's Floors and zones together with the ability of each tenant to view their Billing Data and associated floor energy performance profiles together with recharges and Energy usage for Out Of Hours, and Common Areas usage including Lifts, The EMS system therefore must be flexible to provide:
  - The ability to establish current energy consumption, costs and carbon emissions based on 15 minute usage data.
  - The ability to compare current consumption with historical data.
  - The ability to compare current consumption with other targets or benchmarks such as Degree Days or Floor area.
  - The ability to connect to a Local Weather Stations via RSS feed to provide Temperature / Humidity data for use with actual Degree data analysis together with Wind and Pressure,

- The facility to set future targets and identify trends in consumption.
- The ability to automatically validate the Utility data against the respective Check Meters.

The Metering & Billing data analysis software shall also be setup to provide CUSUM, regression-analysis and degree-day adjustment methods to provide detailed interpretation of consumption data.

All reports shall be designed to clearly show results and shall also be capable of being exported to an Excel spreadsheet for further analysis or for being emailed to required recipients. Additionally, the BMS specialist shall setup a number of standard reports that shall be saved in a template library.

The setting up of the Metering & Billing Software, Meter Tree's, Displays, Invoice Bills and Reports shall be carried out by the BMS specialist who shall provide a technical submittal for comment.

Data Validation

The Metering & Billing Software system shall validate all data entry, whether it is by automatic collection or manual entry using the following methods as a minimum:

- Comparison of data collected with previous readings
- Confirmation that the number of digits correct
- Confirmation that the HHD figures fall within an expected range
- Confirmation that the correct units have been used
- Confirmation that the meter readings correlate with Check Meter readings
- Confirmation that the data collected correlates to the correct time period and that HHD has no missing data
- Confirmation that the Billing Data correlates with the Check Meters for each respective billing period

Data Analysis

Analysis of energy data shall take place for comparison of the actual energy usage with the expected energy consumption and other published energy consumption benchmarks. The main methods of analysing energy consumption data in terms of performance indicators shall be as follows:

- Standard comparison benchmarks shall be produced in order to determine how the building compares with other similar building and best practice buildings.
- Performance lines shall be produced in order to check whether the services continue to function in relation to other key variables such as variations in system energy consumption with degree-days or building occupancy profiles.
- Historical data shall be produced for comparison with previous measurements to ascertain whether any adopted Energy Efficiency Measurements (EEM's) have been effective and to also identify the need for further improvement.

Data analysis shall also provide the following facilities:

- Correlation of actual Building Energy usage with Water & Electrical Utility Bills
- Future Target setting against actual performance
- Validation of meter data and reconciliation with billing data

- In accordance with the building's energy metering strategy the Metering System shall be capable of integrating and undertaking calculations and outputting the results into Virtual Meters which can be obtained from any of the following methods:
  - Deduction of one or many actual meter readings from another, the difference being an estimated reading against which a cost can be then estimated and appropriately re-charged.
  - Calculations based on mass flow rate of Air / Water multiplied by temperature differential and the specific heat capacity of the fluid.
  - Calculations based on Fan / Pump hours run multiplied by the absorbed power and load factor.

The EMS system shall also provide alarm notification for any calculated values that fall outside of a specified levels based on:

- Estimation of energy output of heat generating equipment such as Domestic Hot Water Systems shall be calculated by processing data obtained from temperature sensors, water meter, etc. This data shall be used to determine the energy output by summation calculations involving single point signals or by the integration of multiple signals. The energy output shall be presented in the correct energy units.
- Where any load is not metered, Indirect method of energy metering shall be based on hours run whether this has been logged directly via the Metering System for fixed speed motors, or whether the information has been imported from other network devices such as fan inverter drives. The indirect energy metering calculation shall be based on hours run multiplied by the absorbed power and load factor.

Data Gathering, Archiving and Data Export

The EMS system shall continuously gather energy consumption data from all Water & Electricity Utility Check Meters as well as all Water, heating cooling meters Electricity Sub Meters via History files within each of the local Data Collectors, all Meter data is to be stored at Half Hourly Data (HHD) samples to provide at least 30 days of data storage in the event of Network or Metering & Billing Software issues.

The HHD shall be available to be read from the Data Collector History files via oBIX (Open Building Information Exchange) by the Metering and Billing WEB Based system at Half Hourly intervals for Data Analysis, Benchmarking & Energy Targeting purposes.

All Data Collected by the EMS shall be stored and be accessible for analysis for the latest 5 years, after which the system shall automatically archive the first year, thereby always maintain 5 years of current HHD for analysis. The Metering & Billing shall be able to automatically open archive files as needed to display the archived data. Archive files shall be appended with the new data, allowing data to be accumulated over several years. The overwriting of archived data shall not be permitted.

Users shall have the ability to use pre-defined templates or undertake their own data analysis by selecting the required meters from the Meter Tree, selecting the time ranges and output graph types to view and to finally be able to create export PDF reports or to export data to other applications by means of conversion to a comma separated value (CSV), text (TXT)

All HHD collected via Water, Electricity Data Collectors shall be exported via Modbus or BACnet / IP for Data Analysis, Benchmarking & Targeting purposes within the Metering and Billing Package

Metering & Billing Configuration

The Metering and Billing shall have the following capability:

- Unlimited number of metered Utility supplies and meter tree configuration comprising of Sub Station Meters, Building Meters and Sub Metering distribution according to Site, Building, Floors and Zones usage or utility type such as Lighting, Small Power, Mechanical Power, DHWS, Potable Water etc.
- Automatic database configuration for all utility tariff types (Including Feed In tariffs), degree-days and details of standard utilities.
- Additional fields available for defining floor area, hours occupied and population etc.
- Ability to import utility bills via EDI (Electronic Data Interchange), targets and meter readings directly into the Metering & Billing system to validate Billing Information against Building Level Check Meters.
- Ability to analyse Tenant Invoices and Energy profiles both automatically at the beginning of each month and also and on User demand as required.

Data Resilience

The collection of energy consumption data from all Water, electricity Meters together with sub Meters monitoring MCC/MSPB Plant data and Tenants Gas & Water usage shall be logged at Half Hourly Intervals and stored for a minimum of 30 days within each Data Collector before being uploaded to the EMS where accumulated data shall be stored for 5 years before being archived.

In the event of the Metering or Billing System or Network requiring any maintenance and downtime, the stored Data Collected during this period shall be automatically uploaded on re-connection.

Energy Dashboard

The EMS system shall be capable of streaming Live WEB Dashboards either on Displays or Mobiles to both Landlords and Tenants based on their Login credentials and secured access.

Any Dashboards shall be configured to run in “Kiosk Mode” and Users may also choose how often the dashboard refreshes and updates of real time data.

A Landlords Energy Dashboard shall be configured to allow the Landlords Essential Building Energy Information to be displayed in Charts or Table and touch-screens displays with up-to-date information on the energy efficiency and performance of the building.

Tenants Energy Dashboards shall be configured to allow the tenants to view their specific Floor/Zone Energy Information in Charts or Table and touch-screens displays with up-to-date information on the energy efficiency and performance.

2.6 Power and Control Panels

The specialist contractor shall design supply and install all mechanical service power boards, Motor Control Panels (MCC) and control enclosures (CE) for the project. The panels shall incorporate all the necessary equipment and shall be delivered to site complete with internal wiring. All connections shall be arranged within the panel in neat symmetrical and logical manner.

Generally, the panel shall be form 2B type 2 for standard systems, form 3b type 1 for life safety systems and form 1 for BMS control panels. The BMS panels can either be an integral part of the MCC or free standing.

The mechanical services plant and equipment shall be power wired from local mechanical services power boards or motor control centres as appropriate. In general, each main plant item such as an air handling plant and the associated extract system shall be powered from the local form 2B type 2 power board. Associated with this power board shall be the form 1 controls enclosure that shall only contain ELV services. Any LV services such as Transformers shall be located in the power section of the MCC/MSPB.

The panel shall be constructed to industry standards and be complete with Trirated cabling throughout and shall have 3 phase healthy lamps and MID approved electrical meter display on the fascia.

All panels shall be provided with a standard manufacturers finish, and no doors shall exceed 750 mm wide.

The BMS specialist shall provide the power boards for non-life safety equipment form 2B type 2 power boards and associated form 1 control panels for the MEP plant and equipment other than the panel provided as an integral portion of the air source heat pumps, the firefighting smoke control panel and the on floor office air handling CAM unit.

The electrical contractor shall provide 3 phase + neutral power feed to the BMS provided MCCs and make all final connections.

The electrical contractor shall provide power for the remote plant and equipment from distribution boards however, this shall terminate at a local isolator. The BMS specialist shall provide all power wiring from this isolator to the MEP plant and equipment and make all final connections.

The power sections shall be form 2 B type 2 complete with door interlocked isolator and MID approved electrical meter. The panels shall be constructed to BS EN 61439 – 3 and IP65 rated. Where panels are mounted external to the building these shall be housed within a weatherproof enclosure provided by the panel board provider. All externally mounted panels shall have anti-condensation heaters in the control and power section and class 2 surge arrestors.

The power section shall include power feeds for all fans, pumps, trace heating, package plant and associated devices such as thermal wheels, condensate pumps, AHU lights and the LV services associated with the control system such as the LV protection, transformers and panel UPS.

MID approved electrical meters shall be provided within the power section for both individual and groups of plant as identified in the points drawings. These meters shall be connected to the EMS/BMS via Modbus interface through which instantaneous and accumulative heat energy shall be read and recorded.

Where control panels are provided remotely these shall be form 1 and require to be two section, one door interlocked section containing the LV power, UPS and transformers associated with the control system and the other non-door interlocked section can training the ELV DDC controllers and relay logic

The BMS specialist shall provide all power and controls wiring from the BMS provided controls and power panel to the plant and equipment and shall make all final connections.

The BMS specialist shall provide ELV power for services such as valve and damper actuators, heat meters, frost stats and all instrumentation from the ELV BMS provided control panel.

All cabling within panel shall be tri-rated and under no circumstances shall LV cable been mixed with ELV cables in any trunking section.

The power cabling feeding EC motors shall include an on load isolator with auxiliary contacts wired to the EC motor enable circuit. Within the power section the BMS specialist shall provide a contactor that provides power to the fans. This contactor shall be powered via 24 Volt safety circuit linked through lockstop buttons mounted alongside of the supply and extract fan sections and through auxiliary contacts in the fan isolators. When the safety circuit is broken the contactor shall open circuit and only remake when the circuit is healthy, and the reset button is operated. This reset button which forms part of a 3 wire latching circuit and is located within the non-door interlocked section of the control panel.

The power cabling feeding inverters shall be complete an on load isolator with late break early make auxiliary contacts connected to the enable circuit of the inverter.

The MEP plant and equipment shall be controlled by the automatic control specialist supplied DDC web enabled controllers that communicate via the site wide BMS network utilising BACnet/IP. The controller shall be housed within the non-door interlocked section of the control panel and shall be provided with a backlit display mounted on the fascia of the panel. This back lit display shall communicate to the controller using a web browser only with all graphics held within the controller and accessed via the web browser. Where panels are mounted externally a clear plastic hinged cover shall be provided to protect the display screen.

The automatic control specialist shall provide all controls instruments and actuators for the project and wire these to the BMS provided control panel.

The automatic control specialist shall provide all safety interlocks within the control section including but not limited to, fire alarm, damper end switches, high and low-pressure switches, auto reset frost stats. These shall form part of the plant safety interlocks and shall be hardwired to the inverter and/or EC motor safety terminals.

The fascia of the control section shall include control circuit healthy lamp, a system running lamp, a fault lamp and a reset button, the provision of numerous rotary hand off auto switches and run/trip lamps is not required.

The plant status and plant HOA switches shall form part of a GUI displayed on an android style backlit colour display panel. This panel shall be mounted on the fascia of the control enclosure shall act as a browser to the embedded graphics held within main plant controller. The plant graphic, that may be the same as the graphic displayed on the BMS head end supervisor, shall be held within the outstation controller and accessed via this web browser from the display panel. The user shall be able to manipulate and review the plant status directly through this graphic with a user specific password.

Any user shall be able to view the plant status directly through this graphic without any password required. The BMS specialist shall configure for each controller 3 users. User 1 shall have view only access, user 2 shall have the same right as user 1 and be able to access the plant and fan HOA switch, whilst user 3 can access all information using their unique password.

The EC fans and inverters require a manual speed control when operating in a manual mode. This manual speed control limited to a minimum of 20 Hz shall be available to the user through a user adjustable GUI knob displayed on the BMS head end supervisor and at the outstation control panel display unit.

The major alarms when active shall illuminate the panel alarm lamp. When the alarm reset button is operated ALL existing alarms within this local controller shall be cleared.

2.7 Cabling

Responsibility

The Contractor shall be responsible for all controls and power wiring and shall determine the split of power and controls wiring for the project. It is however anticipated that the following may occur with regard to electrical services to mechanical plant:

- The electrical specialist shall provide power wiring to the BMS provided power boards and make all final connections.
- The electrical specialist shall provide all power wiring to the BMS provided remote control panels to a local unswitched fused spur complete with power on neon. The BMS specialist shall make the final connection from the spur to the BMS panel.
- The electrical specialist shall provide all power wiring and make all final connections to the office AHU on floor air handling plants.
- The office on floor AHU specialist shall provide all power wiring and make all final connections between the AHU power/control panel and the fans and associated field equipment.
- The electrical specialist shall provide all power wiring and make all final connections to the office fan tile units.
- The electrical specialist shall provide all power wiring and make all final connections to the packaged air handling plant systems.
- The packaged AHU specialist shall provide all power wiring and make all final connections between the packaged AHU control panel and associated fans, air source heat pumps, lighting and other AHU LV services.
- The electrical specialist shall provide all power wiring and make all final connections to the basement smoke extract fan inverter isolators. The BMS specialist shall provide all power wiring and make all final connections from the inverter isolators through the inverters to the smoke fans.
- The BMS specialist shall provide all power wiring and make all final connections to mechanical services plant and equipment that is powered from BMS provided panels.
- The electrical specialist shall provide all power wiring and make all final connections associated with the sprinkler pumps and firefighting systems.
- The electrical specialist shall provide all power wiring and make all final connections to the staircase Firefighting lift lobby control panels.
- The electrical specialist shall provide all power wiring and make all final terminations to the smoke damper interface units.
- The electrical specialist shall provide all power wiring to the heat maintenance tape system including all final connections from local distribution boards.
- The electrical specialist shall provide all power wiring to the trace heating systems from local distribution boards including all final connections.

- The electrical specialist shall provide all power wiring and make final connections to the DX external condensers and internal fan coil units from local distribution boards.
- The electrical specialist shall provide all power wiring and make final connections to the 4 pipe fan coil units from local mechanical services distribution boards and provide fused unswitched neon spurs
- All controls and ELV instrument and actuator wiring connected to BMS provided panels shall be provided by the BMS specialist.
- The BMS specialist shall provide all power wiring including isolators for all MEP plant and equipment connected to powered from the BMS provided power boards.
- The BMS specialist shall carry out all power and controls wiring associated with the underfloor heating/cooling systems.

Power cabling

All plant and equipment power wiring emanating from the mechanical services power boards shall be suitably rated for the services served. The nonlife safety equipment shall have steel wired armoured cabling or single core cabling in conduit/trunking.

All cabling shall comply fully with the requirements of the electrical specification.

The life safety plant and equipment shall have BS 8519 category 3 for both control and power wiring.

All cables shall be manufactured by a BASEC certified company.

All power cables shall be single core LSF in conduit or trunking and shall be single core XL/LSF 6491B with XLPE/LSF/SWA being used on tray or any exposed surfaces. Low voltage power cables shall have a minimum csa of 2.5mm2 and stranded throughout. With general power cabling single core in conduit or trunking to BS 7211 with LSOH outer sheath with multicore XLPE/SWA/LSZH with 90°C XLPE insulation to BS 5467. Tested in accordance with BS EN 60754 and BS EN 60332.

BMS extra low voltage cables shall have a minimum cross sectional area of 0.75 mm2 (7/0.37 mm dia), with due regard to cable resistance for sensors. All low voltage cables shall be single core, with an LSOH outer sheath and screened, if necessary, to the relevant specification, having stranded copper conductors.

The use of PVC cabling outside of panels shall not be acceptable.

Where cables are mounted externally these shall be protected from UV degradation.

The power cable installation shall include the provision of lockable isolators alongside every plant item. Where isolators are provided for inverter, these shall include late make, early brake auxiliary contacts that shall be wired in series with the inverter safety circuit.

All drives 5kW and above shall have EPOs wired in series with the inverter safety circuit.

All power cabling shall be installed in conduit, trunking or on tray as appropriate.

Controls cabling

The specialist contractor shall provide all control wiring and carrier systems for equipment connected to the MCCs and the CEs.

The ELV signalling controls cabling shall be to a standard required by the control's specialist generally twin twisted pair. These cables shall be run in conduit or trunking, shall be manufactured by a BASEC company and finished with an LSOH outer sheath.

All cabling shall comply fully with the requirements of the electrical specification.

The use of PVC cabling is not permitted; all cables shall have a LSOH outer sheath. Tested in accordance with BS EN 60754 and BS EN 60332.

BMS extra low voltage cables will have a minimum cross sectional area of 0.75 mm2 (7/0.37 mm dia) with due regard to cable resistance for sensors and shall be in conduit or trunking all final connections to equipment shall be via flexible steel conduit. Loose laid controls cabling is not permitted.

All controls cabling shall be screened and shall be located at least 200mm from any power cabling and not run parallel to the ELV/LV system cables.

All controls cabling will be screened, installed within conduit or trunking have a LSOH outer sheath. The final connection to devices may be through flexible galvanised conduit.

Carrier Systems

The cable carrier systems shall be provided by the automatic controls specialists throughout the project. The standard of workmanship shall be as described in the electrical specification. Generally, the controls and power cabling shall be loose laid on medium duty tray or 4 mm precoated electro plated basket with singles in heavy gauge trunking or class 4 galvanised conduit.

Power cables shall be laid on medium duty cable tray or pulled through conduit and trunking. The ELV signalling cable shall be installed in conduit and trunking whilst the network cable may be mounted on basket.

All final connections to plant and equipment shall be via flexible stainless steel conduit.

2.8 BMS System

General

The Building Management System (BMS) will provide control and monitoring for the MEP plant and equipment. The system will be a Direct Digital Control (DDC) type with fully distributed intelligence. The controllers shall be web enabled and the system shall be configured to allow full access via a web browser and be expandable to other systems by use of BACnet or Modbus.

The BMS shall be a Direct Digital Control (DDC) system with an open backbone network conforming to ASHRAE's BACnet/IP protocol standard CEN ISO 16484-5. Where high-level interfaces to other equipment is required, this shall be via a Niagara solution. All BACnet equipment shall be provided with its PIC statement.

The BMS shall incorporate high-level interface to all third party equipment such as the heat pumps, packaged air handling plant and the on floor air handling systems and provide full dynamic graphics of both the systems and all other field and virtual points on the BMS supervisor.

The BMS specialist shall provide two JACE 8000 with 10,000 fully licensed points and MQTT protocols. These points shall generally be available for future integration and remote analytics and shall not be utilised as part of the building operating strategy.

The main plant control panels shall be provided with back lit colour displays that have a GUI for the plant and equipment hand off auto switches. This display panel shall also act as a browser the sitewide BMS.

The BMS head end supervisor shall comprise a server running the application and graphic systems all of which shall generally be viewed via a web browser running on a separate PC. The system shall allow an unlimited number of concurrent users to access the data. The graphics shall be HTML 5 and shall auto size for any screen size and include all field and virtual points.

The BMS shall be provided by a specialist supplier and shall operate an open protocol BACnet solution with freely programmable controllers for both the terminal devices and all central plant.

Central plant controllers

The BMS controllers for the building services plant and equipment shall be direct digital control with distributed intelligence, web enabled and communicate via BACnet.

The control equipment shall be connected to the sitewide BMS via the converged network.

The controller modules shall be located within the control panels and shall be provided with integral hand off auto switch modules. These manual switches shall be used in preference to any rotary switches mounted on the fascia of the control panels.

The controllers shall be web enabled DDC devices with embedded graphics and communicating via BACnet/IP. The central plant controllers shall have UPS support for the control and monitoring system (communications and monitoring only) and shall have fascia mounted backlit LCD display units. These display units with a minimum viewing area of 300 mm, shall display the dynamic embedded graphic via a web browser for each plant item connected to the controller and shall include a GUI for the plant of auto switches and plant running for status. Individual lamps shall be provided on the panel fascia to indicate power available and whole system running for the connected services. An alarm reset button and, alarm lamp shall be provided on each panel such that the critical alarms generate the alarm lamp and all existing faults in the controller are cleared when the alarm reset button is operated.

Head end supervisor

The BMS specialist shall provide a BMS rack mounted web server that shall contain the operating system, the database and all dynamic graphics, the server shall only have software required for the operation of the head end supervisor. The server shall be accessed from any PC with suitable rights utilising a standard web browser. The BMS specialist shall provide a UPS for the server and for each of the BMS provided PCs and where the network switches are provided by the BMS specialist support the network communications and head end for up to (2) hours.

The BMS supervisor shall be N4.

The BMS specialist shall include the provision of 1 PC connected to the BMS network and located in the FM workshop that shall be the primary connection to the BMS server. Normally access to the BMS system shall be via the web browser however with suitable passwords it shall be possible to access the native BMS system allowing reconfiguration of software and where necessary uploading and downloading strategy to be implemented.

The BMS shall be set to provide standard management functions including alarm handling and routing of alarms to particular mobile devices via email. In addition, specific alarms shall be transmitted to the smart building solution where these may be handled in a different manner.

Generally, access to the system configuration software shall be limited to specialist users via password protection, however all set points, time clocks, trend logging, report generation, user rights, alarm reset acknowledgement and the like shall be available to the FM team with grouped rights as appropriate.

Office user interface

The BMS specialist shall provide within each office demise a colour backlit touchscreen display panel with a minimum viewing section of 300 mm. This device shall be connected via an IP connection to the managed switch and in turn back to the sitewide BMS. These display units shall be a web browser to the sitewide BMS however the unit shall be configured to generally display the information associated with the local office AHU and associated fan tile units. The outstations shall hold embedded graphics and/or text pages for the local AHUs and shall be the location in which the room set points are read and adjusted.

Control enclosure display panels

Each central plant control panel shall be provided with a colour backlit touchscreen display panel with a minimum viewing section of 300 mm that shall be the primary interface between the user and the local control system.

The unit shall display all current data associated with the outstation and allow user adjustment as if this were the BMS head end supervisor.

The plant status and plant HOA switches shall form part of a GUI displayed on an android style backlit colour display panel. This panel shall be mounted on the fascia of the control enclosure shall act as a browser to the embedded graphics held within main plant controller. The plant graphic, that may be the same as the graphic displayed on the BMS head end supervisor, shall be held within the controller and accessed via this web browser from the display panel. The user shall be to manipulate and review the plant status directly through this graphic with a user specific password. Any user shall be able to view the plant status directly through this graphic without any password required. The BMS specialist shall configure for each controller 3 users. User 1 shall have view only access, user 2 shall have the same right as user 1 and be able to access the plant and fan HOA switch, whilst user 3 can access all information using their unique password.

Energy monitoring system

The BMS specialist shall provide the energy monitoring system as an integral part of the sitewide BMS.

2.9 Converged Network

The network shall be designed provided and installed by a specialist network supplier. The network specialist shall provide the RJ 45 socket's alongside and preferably within the control panel. Generally, panels will require one socket for the controller, one socket for the screen and a spare for future and commissioning.

2.9.1 BMS Network

The BMS specialist shall provide all BMS networks downstream of the main plant controllers. This will include

- MSTP networks to the terminal VAV units.

- Modbus networks to the EC motors.
- MSTP networks to the inverters.
- Modbus networks to the air source heat pumps.
- Modbus networks to the well-being office floor monitoring sensors.
- Modbus networks to the ATS units.
- BACnet/IP connections to the packaged air handling plants.
- MSTP connections to the packaged air handling plants.
- Installation of the window actuators network.

2.9.2 EMS Network

The BMS specialist shall provide the EMS network that shall incorporate the heat meters, electrical meters, water meters. These networks shall include BACnet/MSTP, Modbus and M-bus. The meters shall be on separate networks to the sitewide BMS and shall terminate at BMS provided outstations for conversion to the BACnet protocol.

2.10 BMS Drawing Register

0010 Legend
0040 Network 1
0045 Network 1
0050 basement panel location
0055 ground floor panel location
0060 Mezzanine panel location
0065 level 1 to 6 panel location
0070 level 7, 8 panel location
0075 level 9, 10, 11 panel location
0085 level roof panel location
0100 Control Panel sheet 1
0105 Control panel sheet 5
0110 Control panel sheet 2
0120 Control panel sheet 3
0130 Control Panel sheet 4
1010 Ventilation sheet 1
1020 Ventilation sheet 2
1030 Ventilation sheet 3
1040 Ventilation sheet 4
1050 ventilation sheet 5
1060 Ventilation sheet 6
2010 Ventilation sheet 7
3010 general control and monitoring sheet 1.

3015	general control and monitoring sheet 2
3020	general control and monitoring sheet 3
3030	general control and monitoring sheet 4
3035	general control and monitoring sheet 5 - windows
5010	heat pumps
5020	circulation pumps
6010	Tenant floor monitoring 1
6020	Tenant floor monitoring 2
6030	Tenant floor monitoring 3
6040	Tenant floor monitoring 4
6050	Tenant floor monitoring 5
7010	Public health services sheet 1
7020	Public health services sheet 2
7030	Public health services sheet 3
8010	Electrical monitoring sheet 1
8020	Electrical monitoring sheet 2

3. AUTOMATIC CONTROLS STANDARDS OF MATERIALS AND WORKMANSHIP

3.1 BMS System Type

The Automatic Control system, or Building Management System (BMS), shall be a Direct Digital Control (DDC) type with fully distributed intelligence. The system shall be configured to allow full access via a web browser and be expandable to other systems by use of native BACnet to ASHRAE's BACnet/IP protocol standard CEN ISO 16484-5 or Modbus and the like, LON shall not be provided.

Where specialist plant and equipment is provided with integral controllers these shall be configured to allow full access via an IP connection and be expandable to other systems by use of native BACnet to ASHRAE's BACnet/IP protocol standard CEN ISO 16484-5 or Modbus and the like, LON shall not be provided.

All equipment shall be provided with a BACnet PIC statement.

3.2 Responsibilities

Design

The BMS and automatic controls specialist will examine all drawings and documentation and will produce for approval the basis of design. The design will incorporate any necessary statutory requirements with respect to Health and Safety.

Supply

The BMS and automatic controls specialist will supply all materials and equipment necessary to be installed for the complete control and monitoring system. All materials and equipment will be suitable for purpose and location. All materials and equipment either manufactured by the BMS or automatic controls specialist or bought from an outside source will conform to all relevant Local Standards. The equipment supplied will all be of a standard type and readily available for replacement in the event of damage or malfunction.

Submittals

The automatic controls specialist shall submit for comment full details and samples of all sensing and controlling equipment to be used on the contract. These submittals will be made within the agreed programme period. The submittals will include physical dimensions and any specialist requirements. Approval of the documents will not relieve the automatic controls specialist of any responsibility in the respect of providing equipment suitable for purpose.

The automatic controls specialist shall submit for comment general arrangement drawings showing the position of all equipment and wiring routes. Approval of the documentation will not relieve the automatic controls specialist of any responsibility for errors or omissions.

The automatic controls specialist will provide for comment, samples of any component that is to be mounted within the occupied space.

The automatic controls specialist will provide block wiring diagrams and schedules appertaining to the interfaces between the automatic controls' specialist works and other parties. All block wiring diagrams will be complete with the contractor's terminal numbers.

Where the controls interfaces with other equipment the automatic controls specialist will co-ordinate the interface wiring diagrams and provide the necessary interface hardware.

Installation

The BMS and automatic controls specialist shall install and wire all equipment necessary for the complete operation of the building management system.

Setting to Work the Automatic Controls

The BMS and automatic controls specialist shall be responsible for setting to work the system of his supply.

Setting to Work the Building Services

It is the responsibility of the contractors to set the building services to work and to leave the systems operating as described in the project specifications.

Monthly Return Visits

The BMS and automatic controls specialist shall include in the contract costs three return visits after contract completion, these shall last for a minimum of two days and there shall be three visits, spring summer and winter.

Handover

The automatic controls specialist shall work in conjunction with all other contractors to enable the complete project to be handed over as set out in the contract documents.

Documentation

The automatic controls specialist shall provide all documentation necessary to allow the user to operate the plant both efficiently and safely. The automatic controls specialist shall provide sufficient information to and co-operate with the mechanical contractor for the production of the building logbook.

System Completion Report

The automatic controls specialist shall provide a close out report that shall include the installation snagging sheets; the commissioning sheets the installation report and the environmental report.

Training

The automatic controls specialist shall train the user's staff in all aspects of the automatic controls and BMS.

Operating and Maintenance Manual

The automatic control specialist shall provide the operating and maintenance manual for the project. The draft manual should be provided at least 6 weeks before the anticipated project completion date.

The manual shall include:

- All description of operations
- Hardcopy of all software
- Hardcopy all graphics
- Hardcopy of panel wiring diagrams
- Schedules of plant and equipment
- Maintenance schedules
- Safe working practices.

The automatic control specialist shall combine the description of operations and panel wiring diagrams into a common file and install this on the BMS server. On each main plant graphic, a link shall be provided to the appropriate section of the description of operation from which a further jump tag shall be provided to the system wiring diagrams. This information should be available during the commissioning period with finalised documentation uploaded at project closure.

3.3 Panels

The power and control panels shall be provided by the specialist supplier and constructed generally in accordance with BS EN 61439 Part 1 2011, Part 2 2011 and Part 6 2012.

The configuration of the panels shall suit the project and would include for the power section: form 3b type 2 for life safety and business critical equipment and form 2 type 2 for all other power requirements all cubicles shall have door interlocked isolators.

Where required for continuous operation the power boards shall be subdivided with separate door interlocked cubicles to serve particular M and E plant items that require to remain operational was of the plant is being maintained.

All panels shall be IP54 rated and where mounted externally shall be complete with anti-condensation heaters in both the power control section. The external panels shall be provided with a weatherproof enclosure complete with viewing panel.

All power boards have a short circuit rating of 20KA and where panels feed externally mounted plant or equipment these shall have class 2 surge protection device.

All control enclosures serving externally mounted plant and equipment shall have class 3 surge protection devices.

The control sections whether or not these are physically part of a power/control panel, commonly called a MCC, shall as a minimum be form 1 non-door interlocked. The control enclosure shall contain ELV services only all controls transformers and LV protection devices shall be within a separate door interlocked panel either being the power section of the common panel or a separate form 1 panel mounted alongside the control enclosure. Where a power socket is required within the controls enclosure

this should be mounted on the sidewall and under no circumstances shall LV cabling be run in the same trunking system as any ELV services.

The panel specialist shall coordinate with MEP equipment suppliers all necessary power feeds, the power feed described in the specification should be considered as a minimum requirement.

All switches, displays, handles and the like shall be positioned between 450mm and 1900 above the general level of the plant room floor. Panels shall not be more than 2200 high and doors shall be no wider than 750 mm.

3.4 Power Boards

The power boards shall contain all 3 phase and single phase power requirements for the MEP plant and equipment. Generally, the power shall be derived through MCBs and feed direct to the associated plant and equipment. Where necessary for such items as immersion heaters either provided with thyristors or fed directly from a contractor the power section shall contain the MCB and contactor. The thyristor may be mounted local to the plant in a separate form 1 door interlocked panel or within the power section of the common power board.

Power Board Identification

All power boards shall be provided with the following identification on the panel fascia:

- A panel identification label.
- The manufacturer's name, construction date and serial number.
- 3 phase power lamps
- MID approved electrical meter.
- The source from which the panel is fed.

Power Meters

All power boards shall be provided with an incoming MID approved power meter complete with visual display and Modbus connectivity.

It should be noted that although inverters provide a power output reading this is not MID approved and therefore where billing is required the meter reading from the inverter will not be appropriate. If however meter readings are required for energy monitoring to meet the building regs then the inverter readings will be acceptable.

3.5 Control Enclosures

The BMS specialist shall provide form 1 control panels that shall contain the DDC controllers, ELV hardwired interlocking relay logic, network controllers IT switches and terminal rails. On the fascia of the panel shall be a back lit display complete with touch screen.

The CEs associated with MCCs shall have all LV equipment such as transformers and LV protection located in the power section of the MCC. The only LV service in the CE shall be the RCD protected socket and this shall be mounted on the side wall between the power section and the controls section.

All controls power required of whatever voltage emanates from these panels.

Control Panel Identification

All control panels shall be provided on the facia with the following:

- A panel identification label
- Manufacturers serial reference number
- Incoming main isolator non-door interlocked.
- Control circuit healthy lamp.
- Control system alarm reset button
- control system HOA switches (wired as digital inputs)
- Fire override ON lamp (Only required systems with smoke fans)
- 13A socket with RCD.
- BMS comms socket.
- BMS touch screen operator panel.
- BMS outstation(s) c/w I/O modules.
- RJ 45 socket.
- 24V AC/DC power supplies.
- Pocket for wiring diagrams.

The controls shall be arranged so that work can be carried out on any circuit in complete safety with all other circuits alive and in service.

3.6 Construction

All panels shall be folded sheet steel construction not less than 2.00 metric gauge or constructed on a modular metric gauge flush sheet steel finishing. Additional supports are to be provided within the panel where required to support heavy items of equipment, instruments, etc Any fixing screws required for removable panels shall be chrome plated and if not, counter sunk screws shall be provided with plated washers. All panel corners shall be radiused. Panel doors shall be fixed with lift-off hinges to facilitate removal. All components must be readily accessible for maintenance with the doors open and any component must be removable without removing the doors.

If large plant items such as power and control enclosures are split for delivery, the Contractor shall include all costs for handling and reassembly and insulation testing of power sections.

The panels shall be dust and damp proof enclosures generally to IEC 529 (BS 60947) IP54 with suitable gaskets provided round the doors and any removable covers. These gaskets are to be expanded PVC fixed by adhesive and, where possible, retained in a metal trim. All access doors shall be fitted with a common key operated lock for the particular project.

All components including those in wire ways such as bus bars bolts shall be accessible and manipulable from the front of the panel. If panels are island mounted access may be from the rear.

All cables, unless agreed with the Client’s Representative, shall enter and leave the panel though gland plates at the top.

Lifting eyes shall be provided for convenience in handling large and heavy panels.

Painting

Before despatch from the manufacturer's works, all exposed metal surfaces of the control cabinets shall be finished as described.

For indoor use, the cabinets shall have two coats of rustproof primer, filled as necessary and flattened to a smooth finish, then two undercoats followed by a final finish of two coats of epoxy resin paint, to an approved colour, the final coat drying to form a hard semi-gloss surface.

For outdoor use, there shall be an additional coat of epoxy resin paint drying to a high gloss finish.

Colours of all internal surfaces for both indoor and outdoor use of sheet steel fabrication shall be white semi-gloss.

External colours shall be to the approval of the Client Representative.

Galvanising

Where galvanising is specified as the finish, it shall be carried out as follows:

Galvanising shall be applied to the galvanising thickness and quality of zinc conforming to BS EN ISO 1461. The zinc coating shall be smooth, clean and uniform thickness and free from defects. The preparation of galvanising itself shall not adversely affect the mechanical properties of the coated material. Sheradising or other special process shall not be used unless approved.

All drilling, punching, cutting and bending of parts shall be completed and all burrs shall be removed before galvanising is carried out.

Care shall be taken not to abrade galvanised or specially treated surfaces. Care shall be taken to remove rust streaks or foreign matter deposited on galvanising during storage, transport or after installation.

Whenever the protective finish is found to be damaged after installation the Automatic Controls specialist shall make good all damage to the satisfaction of the Client Representative.

Should any damage occur to a final finish applied by a manufacturer, the automatic control specialist shall have the on-site repair carried out by the manufacturer.

Cable Entries

Removable undrilled gland plates shall be provided at the top and 230mm above the floor level for terminating all incoming cabling. All plates shall be sealed against the ingress of dirt, dust and moisture. These plates shall be easily detachable for drilling purposes.

All entries for cables shall be easily accessible and marked to correspond with the panel wiring diagram and diagrams for external connections.

Internal Wiring

The main current carrying conductors of each main circuit from the incoming terminals shall be capable of carrying for one second without distress, the through fault current equivalent to the three phase short circuit of the system specified.

The Contractor will wire to the internal control panel isolator a suitably sized 3PH + N power supply. The isolator provided by the Contractor will be capable of being locked in the off position.

Power Wiring (220 Volts and Above)

All controls and power wiring cables shall be tri-rated LS0H insulated cables 2491B/6710B to BS EN 50525 and shall be coloured in accordance with the IET Regulations to indicate differing phases.

All power wiring shall be kept physically segregated from all other wiring and the working voltage shall be indicated on the fixed portion of the associated terminal boards.

Wiring for mains voltage will be to the standard detailed in the electrical specification in phase colours with a minimum size of 7/0.67 mm single or multi-stranded as required. Where such wiring is to be carried across door hinges in looms it will be in flexible cable to the relevant BS with a minimum size of 50/0.25 mm.

Extra low voltage wiring will be carried out in flexible PVC insulated cable with an LSOH outer sheath to the relevant BS with a minimum size of 30/0.25 mm.

All LV wiring shall be 500V grade.

Black cables with colour coded ferrules will not be used for phase cables. Wiring within the panel will be colour coded:

Power circuits - Phase Colours BROWN, BLACK, GREY.

Neutral Conductors – BLUE.

230V AC Control Circuits – BROWN.

Extra Low Voltage AC – ORANGE; and

Earth - Green/Yellow.

Auxiliary and main wiring will be kept separate as far as practicably possible. All internal wiring will have numbered ferrules at each end internal wiring will be securely fixed to the enclosures and will not impede the opening and closing of doors or removal of components. Where possible ‘crimp’ type connections will be used.

Cleats are to be fixed to the control panel structure at sufficient intervals to avoid cable sag. Adequate cable loops must be allowed to accessories on doors to avoid cable stretch.

Busbars

All busbars both main and subsidiary to be manufactured from hard drawn high conductivity copper. The entire busbar system is to be rated to withstand the short circuit time current specified and be fully type tested by an approved body i.e., ASTA.

Provide neutral busbars of same rating as phase busbars.

The busbars to be enclosed in a separate earthed metal chamber, with the main busbar located at the top of the switchboard. All busbar joint surfaces to be tinned or plated and all joints bolted together. Busbar identification, i.e., colour bands, to be provided at regular visible positions.

Consideration to be given to fully insulated busbar assemblies dependant on location/environment and integrity of supply requirements.

Ensure connections between busbars and all switchgear are adequately rated for load and fault current. All connections from the busbar system to protective device should be made in solid copper , where cable

connections are made the cable is to be kept as short as possible. Connection from busbar to protection device will require tests carried out to EN 60439-1: 1994

Ensure all penetrations of live busbars into outgoing circuit compartments or cable chambers are fully shrouded.

Shroud and insulate all live parts, accessible or passing through various compartments.

Neutral Bar or Link

A neutral bar shall be incorporated within the panel and must be of sufficient size to allow for each separate circuit neutral conductor to be connected into a separate circuit terminal.

Arrangement and Installation of Wiring

All wiring shall, as far as possible, be grouped according to the circuits involved. It shall be run in insulated cleats of the limited compression type, flexible tubing, rigid steel conduit or plastic trunking and shall then be taken to terminal boards mounted not less than 230mm above the bottom gland plate or not less than 230mm from the top of the panel, as required. Sharp, tight bends shall be avoided.

All outgoing wiring will be clearly segregated with respect to the 230V and extra low voltage systems.

Bunching of cables into large looms will not be accepted. The maximum number of control cables in any one group will not exceed 25 conductors. Conductors for heavy loads will be routed to ensure adequate cooling and will be separated from control wiring. All unfused cables between bus-bars, isolators or fuses will be routed separately as individual looms.

All controls cables, be it analogue or digital, will be in screened multicore flexible cable. Extra low voltage wiring and connections will be separated from the higher voltages.

Where plastic trunking is used, this shall be halogen free and the cable will not occupy more than 50% of the trunking volume.

All control cables will be permanently identified by means of numbered ferrules. These numbers will be shown on the schematic diagrams where these are used for point-to-point wiring.

All parts of the panel including the door will be earthed. Earth continuity by means of door hinges will not be acceptable.

All incoming/outgoing terminals will be *via* screw type terminals.

At the completion of the contract, all redundant cables within the panel shall be terminated in suitable connectors. All cables of this type will be marked as spare and identified on the record drawings along with the external routing of these spare cables.

All internal wiring is to be identified in the same manner as the internal wiring diagrams.

Cable Termination and Terminals

Each wire shall be separately terminated with an approved crimped terminal to suit the terminal used.

All wires shall have numbered ferrules or sleeves at both ends. The ferrules or sleeves shall be of insulating material, which, except where otherwise specified, shall be white and shall have a glossy finish.

The ferrules or sleeves shall be unaffected by oil or damp. Characters shall be indelibly marked in black.

Where internal wires connect to outgoing terminal with their other end on apparatus with terminal identification different to the wire number, this identification shall be shown on a ferrule or sleeve of a different colour to the one indicating the wire number. Both ferrules and sleeves are to be clearly visible when wire is installed, and the wire number marking is to be fixed nearest to the terminal. This secondary cable identification must be shown on the wiring diagrams.

The outgoing control circuits will be *via* knife-edge disconnect type isolators. The circuits will be fused such that each mechanical system has a separate fuse.

The viewing of the wiring diagrams shall be determined by consultation with the Client Representative before the diagrams are drawn.

Wires shall not be jointed or twisted between terminal points.

Bus wiring shall be fully insulated and run separately.

Terminals and Terminal Boards and Connections

All terminals and terminal boards for small wiring shall be crimped type terminals and for ease of maintenance shall be the snap-on type. For power wiring, terminal boards shall be of the stud type, the studs for which shall be positively locked in position without the use of locknuts. Pinch screw terminal boards will not be permitted.

Double banked terminal rails or terminal rails mounted on the sidewall of the panel shall not be provided.

All connections shall be made on the front to terminal boards. Current shall not be carried through the board by the stud.

Terminal boards shall have separate terminals for incoming and outgoing wires and not more than two wires shall be connected to any one terminal. Five percent spare terminals shall be provided within each section of the terminal assembly. Insulated barriers shall be fixed between adjacent terminals. The height of the barriers and the spacing between terminals shall be such as to give adequate protection whilst allowing easy access to terminals.

Terminals must be provided for the incoming main cable so that the power-wiring Contractor does not have to terminate his cables straight on to the lugs of the main isolator. All terminals must be located so that they are accessible to straight screwdrivers and no terminals may be located behind fixed panel work.

No live metal shall be exposed at the back of the terminal boards. Terminals shall be provided for all spare cores of outgoing multi-cables, where indicated.

Any terminal which may be live when the panel is isolated from the supply shall be clearly identified and shrouded.

All terminal boards associated with circuits shall be provided with covers of transparent insulating material. Such covers shall be sectionalised so that groups of associated terminals may be exposed without uncovering the whole board.

Circuit identification shall be fitted to the fixed portion of terminal boards and not to the loose covers only.

Outgoing terminals connected to equipment with terminal markings different from the internal wires shall be indicated by a double sleeve or ferrule on the internal wires showing both numbers and in a distinctive colour. These shall be shown on all diagrams.

An allowance shall be made on the length of each wire at all connections in order to permit the cutting off and remaking of unsatisfactory connections.

Relays

All electrical relays used within the control panels shall be interchangeable and of the plug-in type with equal number of normally open and normally closed contacts of ratings adequate for their operating duties.

All relay-operating coils shall be rated for continuous duty and protected by a common control circuit fuse.

All relays shall have indicator flags and manual override switch.

Control Circuits

Control circuits shall be 24V.

Where the control system is used as low voltage AC, a transformer shall be supplied at a rating suitable for the control system load of the panel plus 20% spare capacity. The transformer shall be in accordance with BS EN 61558 and shall be provided with an external label of approved type and size letter to the Client Representative's approval.

The primary voltage shall be either 400 or 230 as detailed with tappings giving 410 - 420/430 - 440 or 220, 230, 230, 250 respectively and the secondary voltage (the control system voltage) at full load with rated primary voltage and load power factor of the system. The voltage regulation at this power factor shall not exceed 10%.

A continuous metallic screen shall be interposed between the primary and secondary winding. The screen, together with all non-current carrying parts, shall be bonded together and brought out to an external earth terminal together with either one pole of the secondary winding or the midpoint of the secondary wiring, depending on the system voltage.

Plug top transformers shall not be provided.

BMS keypad and display

Keypads and display panels shall be provided for all control enclosures.

The display panels shall be a colour backlit touchscreen running a browser that should be used to display the embedded graphics held within the DDC control unit.

These displays shall include a user graphic of hand off auto switches and equipment running/fault status in place of physical rotary switches on the control panel fascia.

Selector Switches

Where mechanical selector switches are provided, they shall be of the spring-actuated type and it shall not be possible for the operator to leave them or hold them in mid contact position.

Each life safety or business critical system shall be provided with individual 'Hand/Off/Auto' switches.

If drives have high-speed/low speed switches a hardwired interlock and timer shall be provided to prevent switching immediately between high speed and low speed.

Wherever possible HOA switch functions shall be via a graphical interface rather than physical switches.

Operation in ‘hand’ position

When systems are run in the ‘hand’ position the following shall occur.

All hardwired interlocks shall operate in both the ‘hand’ and ‘auto’ positions of the selector switches whether these are software or physical switches. In addition, fan and pump isolation dampers and valves shall be driven open through hardwired interlocks. The drive shall be started ‘automatically’ once all safety interlocks are satisfied.

Current Transformers

Current transformers for the operation of the apparatus with which they will be associated and for the combined duty of over-current protection and efficiency test for the operation of instruments, ammetering equipment shall comply with the requirements of BS EN 61869.

Current transformers for the operation of the apparatus, with which they will be associated and shall, where appropriate, comply with the requirements of BS 7626.

Current transformers shall be constructed so as to withstand safely the mechanical and thermal stresses set up by a short circuit equal to the full short circuit rating of the associated switchgear. The secondary windings of each set of current transformers shall be earthed at one point only. Each such connection to the earth bar shall be made through a removable link placed in an approved position.

Current transformers shall be capable of withstanding for one minute, without damage, the effect of an accidental open circuit in the secondary circuit with full load in the primary.

The method of securing current transformers in position shall be such that no undue pressure is executed on the windings.

Fuse Protection

The Contractor shall be responsible for setting the overload protection or installing fuses appropriate to the actual loading on each circuit.

Any damage resulting from overloading from improper settings or fuse ratings shall be the Contractor’s responsibility for making good.

Fuses shall be manufactured to comply with the relevant British Standard to the type selected. They shall be supplied to suit the ratings of the circuits protected or as specified.

Fuse links shall be arranged in banks, which shall be easily removable to facilitate wiring and connection and shall, where possible, be mounted on non-ferrous bus bars of adequate cross sectional area and using black connection stems.

Every fuse shall be clearly labelled detailing the circuit numbers and coloured in accordance with EN50005.

Each fuse and line link shall be fully shrouded.

Below each bank of fuses shall be its relative neutral bar connections to the neutral bar shall be made in the same order as the connections to the fuse-ways.

Mounted in suitable trays within the control panel, the manufacturer shall supply and fit 10% or a minimum of two spare fuses of each size fitted in the panel.

HRC cartridge fuses provided in distribution switch and fuse gear shall be the fully enclosed shrouded type, category AC4 or DC4, Class Q1 to BS88 Part 2. They shall be arranged vertically with barriers provided between phases. All live parts shall be fully shrouded.

To ensure correct discrimination between fuses, only one manufacturer's type shall be used, as specified.

HRC fuses shall be used where control circuits are supplied directly from mains power conductors.

Fuses shall be colour coded to the approved colourings and inscribed or labelled to show their ratings.

Fuses to be installed for use with contactor control gear shall be installed to the supply of the contactors.

Fuses installed in plugs and fused connection units shall be sized to suit the rating of the equipment to be protected and comply with BS 1362 for ring main accessories.

The Contractor shall provide manufacturers characteristic curves for all proposed fuses and miniature circuit breakers etc.

Fuse Switches

Fuse switches shall be manufactured to comply with BS EN 60947-3. Fuse switch type and ratings shall be as detailed on the drawings where applicable and relevant schedules.

Access to fuse links shall not be possible unless the fuse switch is de-energised. Likewise, it shall not be possible to close the switch while the cover door is open, unless the interlock is purposely defeated. Any parts which remain live when the front cover is open shall be fully shrouded.

All mechanisms shall be non-corrosive.

Arc resistant barriers shall be installed between phases in the vicinity of the arc path.

Isolating switches shall be manufactured to the same standards as fuse switches and shall have fuses replaced by solid links to allow future upgrading to a fuse switch if necessary.

Miniature Circuit Breakers

All miniature circuit breakers shall be rated to withstand the fault currents of the circuits they protect without causing any interference in any other protective device associated with the distribution system. At the same time, the design of the circuit breaker shall be such that it will protect the circuit for which it is intended and not cause or allow other protective devices to operate when fault conditions apply.

Miniature circuit breakers shall be manufactured to comply with BS EN 60898. Circuit breakers shall be type A, B, C or D as appropriate.

All miniature circuit breakers shall be rated to withstand the maximum fault current attainable in the circuit they control.

Where the fault current level is higher than the maximum breaking capacity of the breaker, suitably rated back up fuses or moulded case circuit breakers shall be installed.

The operation of the tripping mechanism shall be instantaneous under short circuit conditions. The fitted magnetic thermal or magnetic hydraulic time delay shall be designed to give a delay on tripping inversely proportional to the magnitude of the circuit current.

Residual current operated circuit breakers

All residual current operated circuit breakers shall comply with BSEN 61009.

Operating residual current is indicated in the appropriate distribution schedule.

Earthing

All non-current carrying metalwork of the panels shall be suitably and adequately bonded to the main earth bar to form an integral part of the panel.

The earth bar shall be high conductivity copper for each panel and shall be sized to suit the fault level specified on the main single line schematic diagrams.

A 25mm x 3mm earth bar shall extend the full length of the panel and supported at intervals not exceeding 1m.

The earth bar shall be bolted to the main frame of the panel and be made suitable for coupling earth bars of adjacent switchboards. All joints shall be tinned, sweated and bolted.

Connections to the main earth bar shall be taken from all panel instruments, relays, meters, star points of current transformers and voltage transformer metal enclosures.

Hinged panels or doors shall have flexible earth connections to the panel main frame, which shall be of a minimum conductor size of $4mm^2$.

Earth continuity on bolted sections shall be achieved by removing any excess paint from bolts or studs before washers are fitted.

Panel heating or ventilation

Where the panels contain inverters, thyristors or any heat generating equipment, the panel shall be supplied complete with mechanical ventilation. The fans shall be enabled through a hardwired thermostat to maintain a maximum internal temperature of 30°C.

Where panels may be located in cold or damp environments internal heaters shall be provided, both in the starter and controls sections.

Laptop Power

A twin socket with RCD protection shall be installed in the controls section of the panel.

Drawing Holder

The control panel manufacturer shall provide within the panel a waterproof rigid plastic container fixed to the inside of one of the access doors. Immediately after commissioning, the Contractor is to place in this plastic container a complete set of panel internal wiring diagrams, external wiring diagrams, fuse charts, spare parts list, maintenance and operating instructions. These are related to the control panel and are additional to any record drawings called for elsewhere.

Laptop shelf

The control panel shall have on the inside of one door a drop-down shelf suitable for use by laptop computer.

Ease of Maintenance

The equipment shall be constructed to facilitate maintenance. All parts subjected to heavy wear and which may need replacement in the course of normal maintenance shall be capable of replacement without major dismantling of sound parts of the equipment.

All specially fitted parts, such as doors shall be clearly marked in relation to their housings to ensure that they cannot be inadvertently interchanged with other similar parts in the equipment.

All panel keys will be the same type.

Component Labelling

All components shall be labelled or otherwise designed to permit them to be readily identified on the circuit diagram.

In the case of any small components, which may be replaced as unit in the course of maintenance, the labelling should preferably be on the equipment adjacent the component, and ideally engraved on the trunking lid in white letters 3mm high on a black background.

All sections of trunking lid shall carry identification references at each end to facilitate correct replacement within the panel.

Name Plates and Labels

Nameplates and labels shall be provided for all starters and items of equipment on the panel front. The labels shall be non-corrosive metal or traffolyte phenolic engraving material. They shall be engraved to give black letters on white background.

Where ‘DANGER’ labels are required, these shall be white letters on a red background.

All identification plates shall be held in place by escutcheon nails, screws or rivets, finished black in colour.

Each section of the panel shall be identified by a nameplate either reading ‘Control Section’ or ‘Power Section’ in addition; all sections shall be identified by a nameplate reading ‘Danger 400V or 230V Live Terminals’ as appropriate.

In addition, each panel shall have a panel reference and manufacturers nameplate.

3.7 Field Cables

The automatic control specialist shall provide and install all necessary power and controls cabling and carrier associated with the automatic control system work scope.

All cables shall be manufactured by BASEC approved company.

All cables will be to suit the Contractors system with the minimum sizes as detailed in this document and finished with an LS0H outer sheath.

All cables will be sized to achieve minimal Volt drop.

All cables in a common carrier system shall have the same insulation rating.

PVC cabling shall not be installed outside of the control panel.

Power cables shall generally be to BS EN 50525.

3.7.1 Control Cables

All low voltage cables will be single core insulated Butyl, with an LSOH outer sheath and screened if necessary to the relevant specification, having stranded copper conductors. All BMS system wiring will conform to the current edition of the IET regulations. Cables will not be connected directly to the DDC devices. All cables will terminate at screwed terminals and subsequently be wired to the DDC device. Electrical screening will be provided to the extra low voltage cable by the use of screened cable.

All controls wiring will be carried out in twisted pair cables, each pair being individually screened. If multicore cables are used then, if acceptable to the automatic controls' specialist, a common outer screen may be employed. Multicore cables may be used so long as all conductors are terminated on the DDC device. Any unused conductors will be terminated to earth at both ends.

Automatic control extra low voltage cables will have a minimum cross sectional area of 0.75 mm^2 (7/0.37 mm dia). With due regard to cable resistance for sensors.

Low voltage cables will have a minimum cross sectional area of 2.5 mm^2.

Screening will be provided by an aluminium/polyester foil shield with a multistrand drain wire (7/0.37). All low voltage control cables will be sheathed in LSOH material.

All controls cabling, including the BMS network will be installed in conduit or trunking.

3.7.2 Power Cables

All power cables within conduit or trunking shall be single core XL/LSF 6491B, XLPE/LSF/SWA shall be used for tray or any exposed surfaces. The minimum cross-sectional area shall be 4mm^2. Conductors shall be stranded throughout.

Cables within a common trunking/conduit system shall be of the same insulation grade

- 600V/1000V for LV services.
- 300/500 V for ELV services.

3.8 Cable Carrier Systems

Cable cleats and supports

All cleats or supports for single core cables shall be manufactured from non-magnetic material.

Cables Run in Service and Pipe Ducts

Cables run in service ducts shall be run at least 25mm clear of walls on galvanised steel hangers or claw type clamps.

Cable carrier systems

All cables shall be in conduit, trunking or on trays as appropriate.

Cable trays

All cable trays shall be manufactured from sheet steel to BS1449 and to a galvanised finish to BS EN ISO 1461.

Cable racks

Cable racks shall be manufactured of mild steel channel sections to BS1449 Part 1 and hot dipped galvanised after manufacture to BS EN ISO 1461.

Fixings

Fixings to brickwork and concrete shall be by woodscrews and suitable raw plugs, grouted type bolts or expanding bolts.

Trunking

All steel trunking shall be manufactured from rust proofed mild steel to BS1449 Part 1 and hot dipped galvanised to BS EN ISO 1461 after manufacture. Trunking shall also comply with BS EN 50085.

Conduits

Steel conduits shall be Class ‘B’ heavy gauge seam welded type and shall be manufactured to comply with BS31, BS EN 60423, BS EN 50086.

3.9 Earthing

The Contractor shall install all earth bonding of services provided by themselves.

Earthing systems shall fully comply with the current edition of the BS7671 and BS 7430.

Protection against indirect contact shall be by utilising the over current protective devices for earthed equipotential bonding and automatic disconnection of supply.

All metalwork which may provide a path to earth shall be bonded to the earthing system.

The resistance between any points on the bonded system and main earth shall not exceed 0.5ohms.

Low voltage switchboards shall be provided with a 25 x 3mm copper tape to which all-electrical apparatus shall be connected to form a continuous bonded earth system directly connected to the earth point.

Tapes 25 x 3mm shall be fixed at intervals not exceeding 600mm intervals.

All extraneous conductive parts and metalwork shall be solidly bonded by supplementary bonding conductors of minimum size 6mm^2.

Cables shall be LSF sheathed and coloured Green/Yellow.

All bonding conductors shall be concealed by a surface or flush conduit system as appropriate.

All protective conductor cables shall be connected by properly sized lugs crimped to the cable.

3.10 Circuit Identification and Labelling

All switch fuse gear shall be clearly identified with an engraved three-part laminate ‘traffolyte’ label with a minimum of 6mm high black lettering on a white background to show their functions.

Standard colour phase buttons shall be fixed on the outside of all switch and fuse gear to indicate to which phases of the supply the various circuits are connected.

All labels and phase buttons shall be secured by brass BE instrument headed bolts and nuts and each label shall be fixed with at least two bolts.

All switchgear shall be labelled with the number detailed on the electrical drawings together with a description of its function.

Each distribution board shall be fitted with a clear plastic wallet on the inside of the enclosure door and be fitted with all relevant distribution board charts for individual circuits showing circuit reference, description and number of points fed, location, cable size etc

In addition to this the Contractor shall supply and install an as fitted non-fading drawing, black on white print of the single line diagram mounted in a glazed wooden frame next to each main switchgear.

The drawing shall be to the size of the original schematic working drawing.

All danger and warning labels shall have black lettering on a yellow background.

All proposed label inscriptions shall be submitted to the consulting engineer for approval prior to installation.

All external lights, switches and other remote circuits shall be labelled with the circuit reference to which they are served from.

Identification markers for cables etc shall clearly identify the circuit reference or cable number.

3.11 IET Wiring Regulations and British Standards

Full compliance is required with the current edition of BS7671 and all relevant British Standards Codes of Practice including all amendments thereto current at the date of tender.

Full compliance will be required with the latest appropriate British Standards Specifications issued in respect of all materials used on the project.

3.12 Electrical Services Testing and Commissioning

Upon completion of the works, the whole installation shall be inspected and tested by the Contractor in accordance with the IET Wiring Regulations and shall submit the completion and test certificate forms for approval by the consulting engineer.

3.13 Safety Interlocks

For every plant item, there will be a number of hard-wired interlocks required. The almost exclusive need for these is for safety. It is therefore necessary that all interlocks operate in both the hand and automatic operation of the MCC mounted Hand / Off / auto switches.

BMS Monitoring and Action

To prevent mismatch alarms occurring the BMS shall mimic the operation of the hard-wired interlocks such that unnecessary alarms are not generated.

Individual Plant isolation

Each plant item shall have a local isolator, capable of being locked in the off position. Each isolator serving a motor shall have auxiliary early break late make contacts wired to the motor control circuit. This shall prevent motors starting in 'Delta' configuration.

Each motor equal to and greater than 7.5kW shall have the isolator and a key reset lockstop button.

AHU Frost Thermostats

AHU's that are not provided with LTHW frost protection coil and perhaps have recuporators, thermal wheels, run around coil is the first heating coil shall have a frost stat complete with a 0 to 10 minute hardwired timer. If the frost stat trips the timer shall be initiated, and the AHU shut down if the timer has timed out and the frost stat has not reset.

When the frost condition is active, the fan shall stop and close any AHU isolation dampers, through hardwired interlocks. All frost stats shall auto reset and the plant restart. However, if the stat has tripped three times in the previous (24) hours, a software alarm reset shall be required before the plant shall restart.

All frost stats associated with externally mounted plant shall be provide with integral heater.

Fan Isolation Dampers

Where AHUs or fan sets, have local isolation dampers these shall be hardwired interlocked with the fan control circuit. The fan shall only start if the dampers are proven open through end switch monitoring. If the fan selector switch is in the 'HAND' position, the dampers shall be driven open through hardwired interlocks.

The damper and fan shall have separate BMS commands.

Duct High/Low Pressure Cut Out

Where systems have duct mounted motorised dampers forming part of a smoke control strategy, the duct system shall be protected by high and low-pressure switches.

The switches if active shall stop the appropriate fans through a hardwired interlock. This shall also initiate a 0-10 minute timer that shall prevent the fan start up until the switch is clear and the timer has timed out.

If the systems are used for normal and smoke control purposes the cut out shall be linked out in the fire mode operation.

Inverters

Each inverter shall be provided with a separate input forming part of the safety circuit, this input should be separate from the normal enable signal.

Within this safety circuit to be such things as: fan isolation damper proven open, fire healthy, other paired drive not running, pressurisation unit low pressure healthy, isolator closed, lockstop healthy.

3.14 Field Equipment

The BMS specialist shall determine the field instruments and actuators required for the project based on information provided in the project specification, existing documents and site visits.

All field mounted equipment shall be suitable for the environment in which it is located and/or operating. Equipment outside the building shall be IP65 rated without the use of protective bags.

All controls field devices shall be ELV.

All field mounted control devices and cables will be of the 24V type. If field mounted equipment provided by others operates from a 230V control circuit, then the BMS Contractor will install an interposing relay either within the OEM plant or immediately adjacent to it.

Valve & actuators

The actuators are to be suitable for the driven device and valves shall not be of the thermic type, shoe type or driven by raise lower modules. All valves, other than those associated with terminal units such as fan coils, shall have external position indicators.

Any flying leads associated with the actuators are to be of a LSOH material and have a maximum length of 1500 mm. Where the dampers are used for fire or smoke control the control cabling shall be fire rated.

In the event of power supply failure, all safety valves shall be arranged to either close or open to reach a safe condition.

The hydraulic static pressure can be considered to be sixteen bar with a differential of 500 Kpa.

All control valves shall be 0 to 10 V modulating 2 port PICV. Control valves shall a full stroke irrespective of any permanent adjustment required to set the maximum flowrate.

Damper actuators

All damper actuators shall be sized to suit the damper torque. For tender purposes, the contractor shall assume 3 actuators per damper to be controlled. All damper actuators shall have external indicators. All damper actuators shall have end switches for monitoring purposes.

Any flying leads associated with the actuators are to be of a LSOH material and have a maximum length of 1500 mm. Where the dampers are used for fire or smoke control the control cabling shall be fire rated.

Sensors

All sensors shall be selected to CIBSE standards and installed in accordance with the Building Controls Group document – Control Sensor Installation.

3.15 Standards Codes and Regulations

The Automatic Controls will be designed, installed, tested and commissioned in accordance with the following:

- Statutory Acts

- Local Standards and Standard Codes of Practice
- Local Authority Building Regulations
- Health & Safety at Work Act
- The requirements of the relevant Local Authority
- The requirements of the relevant Water Authority
- The requirements of the relevant Fire Authority
- The fire officers' committees/the loss prevention councils' rules and recommendations
- The Factories Act
- Current Institute of Plumbing Standards
- The current Electrical Regulations with amendments
- The Environmental Health and Safety Office
- Manufacturers Recommendations for Installation Testing Commissioning
- The Landlord's Regulations and Approvals.
- Reference shall be made to BS 7002, BS EN 55022, BS EN 61000, BS EN 55014, BS EN 60439, CIBSE Guides and Commissioning Code C, BS EN ISO 9000 and the Controls Group Publications.

3.16 Restricted Materials

No materials shall be installed which may pose a hazard to health of the construction, maintenance or eventual occupants of the building;

No materials shall be installed which are potentially damaging to the Environment and as described in the European commission for the environment- Red list of building materials.

3.17 Quality Control

The contract will be carried out under following the principles of the BMS specialist's Quality Assurance documentation.

- All equipment supplied will receive commercial tests to comply with IET Regulations.
- All equipment will be CE marked.
- No materials shall be installed which may pose a hazard to health of the construction, maintenance or eventual occupants of the building.
- No materials shall be installed which are potentially damaging to the Environment.

All electrical equipment shall be designed and fitted with interference suppression devices to comply with BS EN 6100-4-3 and components and filter units shall comply with BSEN 55011-1A.

3.18 DDC Controller

The Automatic Control Specialist will provide all necessary DDC devices to fulfil the complete requirements of the automatic control system and mount these within the controls enclosure.

The automatic control specialist shall provide all licences for the controllers provided for the project and ensure licensing be continuous for at least 5 years after the project completion.

The main plant devices shall be web enabled and complete with embedded graphics and communicate via BACnet/IP, whilst the terminal devices shall utilise BACnet/MSTP.

At least one DDC device within the project shall be a JACE 8000 or equivalent and shall be fully licensed for 10,000 points.

Generally, each mechanical system shall be provided with a separate master controller even where systems are installed within the same control enclosure. As an example, ventilation plant shall have separate controllers to pumped systems.

The extension I/O modules associated with the controllers shall be contained within the control enclosure, under no circumstances shall extension I/O modules be located remotely.

Each DDC device will contain sufficient resident software and data storage capability to fulfil the operational functions detailed in the specification, schedules and drawings. The control enclosure will contain all the interfacing equipment between plant and equipment such that the CPU/DDC device software is fully compatible with any such plant and equipment.

DDC devices will have a standalone capability such that a failure of the CPU will still permit the plant and controls associated with the DDC devices to continue to operate normally. In the event of transmission failure, the DDC devices will continue to operate with all sequence interlocks and control strategies operating normally excepting those that require global information. Default will then be assumed for these global parameters.

Control enclosures will be provided to house all the de-coding devices, interface relays where required, transducers and reset devices. The programmable software in the DDC device will be capable of being updated from the CPU. It will also be possible to program the DDC device from a portable plug in terminal. Any changes made locally will be automatically uploaded to the CPU.

DDC devices will incorporate a self-test facility and be able to provide the CPU with status information concerning their internal operations. This information will include, but not be limited to -

- Data transmission conditions and verification.
- Internal status.
- Battery condition, where applicable.

Any DDC device failure will raise a critical alarm.

The DDC device will be capable of accepting digital, analogue, pulse and pulsed inputs and providing digital and analogue outputs.

Where AO are specified in the BMS schedules a pair of BO will not be considered as an acceptable alternative.

Multiplexes or any other device making use of a single analogue output to switch or monitor numerous shall input/outputs will not be acceptable.

Capacity

Each DDC device will be provided with capacity and memory for future additions of at least 25% of each type of point. These spare points shall be wired to the terminal rails.

This memory will be sufficient to allow all programs associated with all points to be run in the DDC device. The BMS specialist will state in his offer how many such points are actually available for each DDC device.

The control enclosures will be constructed so that the cabinets and internal terminal strips can be mounted, and electrical terminations made, with all electronics being added at a later date during the testing and commissioning phases of the project. The DDC devices will be provided with their own internal battery back-up power supply capable of maintaining the memory for not less than 72 hours.

Interface

The BMS specialist will provide all necessary outstations to fulfil the complete requirements of the BMS.

Outstation interfaces with sensors and operating devices.

- Digital inputs - electric power for contacts will be provided by the outstation.
- Digital outputs - The contact output signals rated at 2A inductive will be suitable for operating remote devices with 230-Volt 50Hz coils.
- Digital inputs and outputs - If the Contractor's system requires any other form of interfacing than those for the systems detailed previously, he will provide all necessary interfacing elements for each remote sensor and device. Where voltage change of state is used, it will be the Automatic Controls specialist responsibility to ensure that the remote sensors and operating devices including those supplied by others are compatible with the system offered.

All analogue temperature sensors will have a resolution not exceeding 0.25°C accuracy better than +0.5°C and stability at least equal to Platinum resistance thermometers of Class 1 standard.

Analogue outputs - Out signals will be (4.20 mA, 0-1 Volt DC, 0-10 volts DC).

3.19 Electrical Supply

The equipment supplied will be suitable for operation on 400/230V, 50Hz supplies and the supply voltage and frequency tolerances permitted by the Electricity Supply Regulations and the Electricity Board Regulations.

The BMS specialist will provide all necessary screening and earthing to both the wiring and the control/outstation panels to prevent corruption of the control's installation. Due consideration will be taken of the effect of handheld radios and pagers within the vicinity of the system.

The complete controls installation will be protected from the effects of electronic interference and in turn will limit its interference to other sources all as outlined in the latest EMC Regulations. Particular care is to be paid to inverters which are to be fitted with internal RFI filters.

3.20 Inverters

The Contractor supplying the inverter shall set to work and commission the units to match the BMS operations. The inverter supplier shall be responsible for all technical aspects of the inverters as described both in the mechanical specification and within this document.

The BMS specialist shall, however, provide management of all inverters and shall provide support during commissioning to establish the operation of all inverters.

All inverters shall be placed local to the plant and shall be IP54 rated. If the plant is external to the building, the inverter shall be located either in the plant housing or in an IP 65 enclosure provided and installed by the inverter supplier. Any externally mounted panels shall be provided with internal heating by the panel provider.

Where isolators are provided for inverters, these shall be lockable and shall include late make early brake auxiliary contacts that shall be wired in series with the inverter safety circuit.

All inverters shall be complete with RF filters.

All inverters' keypads shall be brought to the front of any enclosure, allowing operation and interrogation without opening the panel and where mounted external to the building shall be covered with a weatherproof but clear plastic lid.

All inverters provided for the contract shall be to the standard described in this specification. Under no circumstances shall inverters require the exclusive use of remote wireless connected device and every inverter shall have a physically connected visual display of the operating parameters and allow local manual operation. Every inverter shall be provided with a separate pair of terminals that can be configured as a safety interlock.

All inverters associated with ventilation systems shall have programmable terminals for fire override and Jog speed commands.

All inverters shall have programmable inputs that form part of the safety circuit that prevent operation either locally or remotely unless this circuit is healthy.

Where the AHU is provided with an inverter this shall be mounted in an IP 5X enclosure on the side or local to the AHU. The inverter shall be complete with BACnet/Modbus for high level integration to the sitewide BMS with hardwired connections for enable/speed control and status monitoring.

3.21 EC Motors

The AHU specialist when providing EC motors shall interconnect all internal motor power requirements and terminate in a common lockable 4 pole isolator mounted on the outside of the fan enclosure. The power wiring from the isolated to the individual motors shall be provided with local MCBs cable/motor protection.

The AHU specialist shall interconnect the Modbus monitoring circuitry for each motor drive and terminate in a junction box in the outside of the fan enclosure. The AHU specialist shall provide interconnecting cabling between all motors for the common external 0-10 V speed control signal and the enable signal and terminate this in a suitable junction box on the outside of the fan enclosure.

The monitoring of the fan status (running/fault) shall be via a common output interconnecting between the motors and terminating at a volt free contact in a junction box on the fan enclosure.

The Modbus shall be used for general motor monitoring.

As it is not possible to provide manual speed control by using local keypads (as is possible with an inverter), the Automatic Controls specialist shall provide this function using the AHU controller. To achieve this the AHU keypad shall provide user graphics allowing plants to be set to manual control and user adjustable knobs to set the operating speeds of the drive.

3.22 Software

The automatic controls and BMS specialists shall develop the automatic controls functional design specification and expand this to a detailed description of operation.

The functional design specification should set out in straightforward language the plant operation and user management interfaces. The BMS specialist shall make use of the existing uploaded backwards engineered control strategy, standard operating strategies and enhanced energy management implementation.

The BMS specialist shall discuss and agree with both the client, the facilities management team and the clients' consultants the final agreed functional design specification. This work should be carried out in a series of workshops at which all parties shall be invited to make suggestions and receive detailed advice on the agreed solution for the operation of each plant item.

The BMS specialist shall then develop this functional design specification to include necessary hardware and software points along with any necessary wiring diagrams.

The BMS specialist shall finally design and produce the plant functional operating control strategy and implement this across the site.

All software and firmware shall be supplied to include all the functions generally described in this specification.

Restriction of access to the system for security proposes shall be accomplished by provision of a software based password system.

The basic algorithms necessary for all the software shall be produced by the automatic control specialist after consultation with the Client Representative and then programmed into the system. It is the automatic controls specialist responsibility to design and produce the software and ensure it adequately performs the required tasks.

The software should be written in such a way that the user can have sufficient access to alter significant parameters in relation to the operation of plant. The purpose of this requirement is to allow alteration of plant systems operations, either because of plant modifications or additions, or because experience in use shows that alteration is necessary. This applies whether the routine is provided in standard form or is specially written for the Employer.

All system references to dates shall be in calendar form, e.g., 17.02.2001.

Direct Digital Control (DDC)

This is the use of software-based algorithms, to achieve on/off proportional, proportional plus integral and proportional plus integral plus derivative control loops. The control parameters will be adjustable by keypad operation and via a laptop.

The automatic control specialist will determine and include in the tender bid, the most appropriate form of control to each system.

The software will be suitable for at least four sequential stages of control, the provision of dead zones between stages, control point reset, compensated stages and hardware and software override functions.

The automatic control specialist will be responsible for setting up the software parameters for each process loop, including the setting of the proportional bands, integral times and derivative rates, which will all be site adjustable and recorded in engineering units. All settings will be such that each process loop performs within the required tolerances and that there is no hunting (cycling) of final control elements.

A complete schedule of settings will be provided at final acceptance. The facility will also be provided for the operator to change, via password access, the settings for all process loops.

DDC will normally be operated from software resident in the outstations. DDC software held in outstations will be capable of stand-alone operation, with supervisory commands normally being received from the graphical user interface. In the event of failure at the outstation, the process plant will fail-safe. No DDC loop will be dependent, for normal operation, on the uninterrupted operation of the CPU.

Logic Diagrams

The Automatic Controls specialist will provide a full set of flow charts or logic diagrams to show the software logic for all the performance requirements of each and every plant. These charts/diagrams will describe both the logical sequence and priority levels of all functional and sequential operations.

The system will be designed to fail safe in the event of outstation mains power failure.

The as built logic diagrams will form part of the O&M manual information.

Non-Corruption of Software

The system as a whole shall be designed so that software has adequate protection from corruption arising from:

- Disturbances due to magnetic, electrical, atmospheric or environmental influences, including noise or failure in the electrical supply.
- Switching either the Central Controller or peripherals or outstations on or off.
- Testing either the Central Controller or peripherals or outstations.

In the event of software loss, due to failure of power supplies or for other reasons, it shall be possible to re-establish the system software, including such parameter settings as were previously in use, by re-booting from disc. The responsibility for updating back-up discs of system software, from time to time, shall be the Employers, but the provision of such a facility shall be made by the automatic control specialist.

Note that any software ‘permanently’ held in devices such as ROM, which are intrinsically non-volatile, need not be backed up by disc storage, but details of user specific data must be provided.

All programs will be tried and tested standard programs. The use of unique programs unless for special control functions will not be permitted. If the BMS specialist considers that special programs are required then these will be clearly identified at the time of tender.

The automatic control system will be provided with software programs capable of providing the facilities and features detailed in the specification. The Automatic Controls specialist will demonstrate the operation of each program at his works. The demonstration will include whatever validation tests are required by the Client Representative and be carried out in his presence.

All stipulated software will be provided irrespective of whether the performance requirements or detailed point schedules include for the particular facilities, so as to permit future extensions to the system by the addition of further sensors, detectors, outstations and associated wiring, and/or the input of extra data for various programs.

The master format user interface to the software programs will permit non-skilled operators to operate the normal routines for the plant systems by plain English screened messages, which provide question and answer routines and/or menu type solutions to the standard programs. A ‘HELP’ or ‘SOS’ input routine will be provided, with a printed instruction card, in order to gain initial access to the various software facilities.

All data and messages displayed on VDU’s and printers will be prefaced by the date and time at which the event occurs.

It will be possible to assign values, from the keyboard to any digital, analogue or measured signal so that the specified performance responses may be checked and tested against the requirements.

Network Transmission Speed

The software and hardware configuration will be such that data transmission and operational sequences do not obstruct each other and cause delays to, or erasures of, the receipt of alarms, analogue and graphic displays and the input of keyboard commands. The following specific requirements will also be met:

- Critical alarms will be displayed within 5 secs of occurrence.
- Normal alarms will be displayed within 10 secs of occurrence.
- Graphic displays will start to be displayed on the screen within 5 secs of the command for such a display and be completed within 10 secs of the command, complete with actual values, alarm values and status.
- The value of all analogue inputs will be checked at intervals not exceeding 10 secs, unless otherwise stipulated. Where shorter intervals are relevant, because of short time constants in a system they will be used.
- The graphics will be automatically refreshed every 10 secs.

Access Levels

Operator access to software for amendment, updating and changing of parameter values will be at several different levels ranging from direct access, through a minimum of four levels of password security.

The Contractor will:

- Provide, to the Client Representative, access to the software of the system and details of password security up to the highest operator level, in order to permit listings to be changed on site.
- State which application software programs are run in the outstations, which are run from the CPU, and the level of updating possible for each, from the CPU and at the outstations.

- Include for programming all the functional sequences detailed including printed messages and the generation of colour graphics to include every point on the system.
- Provide sample drawings of the graphic diagram layouts, for comment, prior to production and demonstrate such graphics prior to site delivery, for approval by the Client Representative, at least two months before the programmed project completion date.
- The Client Representatives reserve the right to be directly involved in certain aspects of the software development e.g., design of the colour graphics and printed messages.

Level One Password

This will allow access to all graphics and data including printing of data. It will not allow any changes to be made to the system.

Level Two Password

As level, one plus amendments to all time zones and amendments to all set points.

Level Three Password

Complete access to the BMS excluding alterations of the control strategy but create own software, create graphics and alter operator passwords.

Level Four Password

Complete access to the BMS.

Head End Manual Control

All connected points will be equipped with a simple facility to be ‘taken out of auto’ and placed in ‘manual’ control at the central (BMS) workstation. This function will be operated from the graphical operator interface and will allow operators to be quickly able to raise and lower set point or drive a point open/closed. Similarly, plant such as pumps/fans/dampers will be manually driven if required whilst retaining all safety interlocks.

Historical Data Programme

The software will enable the storage of specified historical data. The data storage will be capable of holding the information for predetermined periods, for accessing as required, and will then dump the most ancient as more input is loaded e.g., if monthly data is required for a period of a year, then the first month will be discarded when the thirteenth month is complete.

The data to be stored will be that specified and the automatic control specialist will set up the system to incorporate these requirements, but the operator will have the facility to alter or amend the instructions subsequently. The program will be capable of transmitting raw data to store or data that has been refined by calculation by other software programs. The program will also calculate average, mean and standard deviation values of the data prior to storage.

The data logging will include both real time, displayed on the screen, for short-term review and long term historical records. The historical records will allow logging intervals to be adjusted between five seconds

and one hour time periods. The intervening times will be as a minimum one thirty seconds, one minute, five minutes, fifteen minutes and one hour.

The operator will be able to request visual or printed displays of any or all this stored data and the facility will also be provided to transfer the data directly to Excel spread sheets for further manipulation by the operator.

Hard drive storage for the necessary data will be provided as part of the BMS. This shall be capable of storing, as a minimum the following data:

- Analogue inputs – 50% of installed at 1 minute intervals for 1 year.
- Analogue outputs – 50% of installed at 1 minute intervals for 1 year.
- Set points – 50% of installed at 1 minute intervals for 1 year.
- Digital inputs –100% of installed 1000 change of states.
- Digital outputs – 100% of installed 1000 changes of state; and
- Energy metering record retention is detailed in the appropriate sections.

Event Totalisation

The outstation will be programmed to count events such as the number of times a pump or fan system is cycled on or off during a particular period. Event totalisation will be performed on a daily, weekly or monthly basis. The software will be programmed to define a pre-set warning limit. Unique operator specified messages will be generated when the limit is reached at the user interface.

Sensor Default Control

Where sensors, used for controlling plant, fail during operation the controlled devices or the measure sensor value will default to an agreed value.

Thermal Control

The software will allow PID control, resetting, cascade and the like to facilitate the thermodynamic control of the systems.

Control Valve and Actuator Cycling

A function will be programmed within the software to cycle all actuators through their full range of movement once in every 24-hour period. The cycle will be finished in one complete operation. This operation will be automatic and in addition to the normal control or manual operation. Actuators will be cycled at a suitable time to be agreed with the Engineer, alarms will be inhibited, as necessary. The operator will have the option to select any items that are to be excluded from this routine. A report will be generated if positive feedback devices are installed and a mismatch between the cycling and the response is detected.

Run Time Totalisation Program

A run time totalisation program will be provided for application to all items of plant. The system will initiate an identifiable alarm output whenever the pre-set limit has been exceeded for the particular item. The run

time will be determined from positive use of the plant such as differential pressure or running signals from packaged plant.

The run total will be accessible by command from the operator, who will also be able to reset the limits or zero the count for each item, using suitable password access.

Sufficient BMS hard disk storage will be provided to hold all data, for all motors, for two years.

3.23 Alarm Programme

The software within each outstation will scan all alarm inputs in less than five second intervals. On an alarm being generated, the software will take immediate action to rectify the fault.

The alarm will report the status to the user interface where the current function will be halted until the alarm is acknowledged. The acknowledgement will be via password authority. The VDU will clearly show that an alarm has occurred and a brief description be displayed.

The program shall allow the operator to easily change or define each message. Each message will be entered by the automatic controls' specialist from an agreed schedule. The sitewide control system shall be configured to transmit the alarm and an English language message to specific email address.

Plant Mismatch Alarm

Every point will have mis-match alarms set. These include fans and pumps running when told to stop, fans and pumps stopped when called to run, temperature values outside of acceptable range e.g., supply air temperatures < 8°C, >30°C room temperatures < 16°C, > 26°C, chilled water temperatures 2°C above set point, heating systems 5°C above or below set point.

Alarm Inhibition

When an alarm condition is displayed, it will be independent of any other possible alarm or cause that may initiate a string of further alarms. Where such circumstances occur, the software will inhibit any such sequential alarms. The automatic control specialist will co-ordinate such sequences in his detailed design and submit details sufficient to demonstrate compliance with requirements.

The program will inhibit analogue alarms when the associated plant is switched off by the automatic control system. The program will inhibit analogue alarms during the start-up of each plant item. This delay time period will be for a maximum of ten minutes to enable the building service installation to reach stable conditions.

Digital alarms will similarly be delayed at plant start up times for one minute. During normal operation, every alarm point will have a timer than can be set during commissioning to eliminate nuisance alarms.

Alarm Priority

Alarm Priority will be as described in the specification

Head End Alarm Reset

A single reset 'button' will be displayed on each graphic. This will allow any alarm on the displayed system to be reset. This reset action will be recorded on the hard drive and printed. The message will show the fault reset set, its identifier, the operator who reset and the date and time.

Control Panel Alarm Reset

A single reset 'button' shall be provided on the control panel fascia. When operated all current alarms in the local outstations shall be cleared. This reset action will be recorded on the hard drive and printed. The message will show that the reset has been operated along with the date and time.

3.24 Graphics

The BMS specialist shall provide dynamic graphics for all field and virtual points associated with the project.

The controls specialist will allow sufficient time for the production of the graphics. The controls specialist will propose a graphic layout and tree structure, system mismatch and alarm indication. These will be agreed by the Client Representative before detailed graphic are produced.

The controls specialist will supply sufficient software and training to allow the operator, post contract, to construct fully functional dynamic graphics. The dynamic points will include all installed equipment and allow the operator to build graphics and manipulate the points to provide full read and write functions.

Graphic shall be provided on a system by system basis **not** panel by panel.

General

Every field and virtual point of the system is to be displayed as a dynamic value on the appropriate system graph. The graphic display is to be as clean as possible and constructed in a simple to read form.

The controls specialist shall provide dynamic graphics for all plant that the BMS controls and monitors.

The operator interface to the BMS will normally be through the dynamic graphic route. It is therefore important that the structure of the layers is simple to follow and meaningful. The controls specialist may suggest any reasonable solution. The following is for general guidance.

- The log-on page will be a simple and clear text driven page with fields for the operator's name and passwords. This will then access a silhouette of the building. Where more than one site is accessible from the head end these will all be displayed on a site plan with identifiers and click boxes
- The building silhouette will be divided floor by floor. Each major plant floor area will be identified and accessed through the click boxes
- In addition to all the necessary major plant graphics each floor will be accessible. The floor selected will be shown in plan view on the screen. The offices and cores on the floors are to be shown with reasonable accuracy. Each area is to be identified either by a room number or name. Where terminal devices are installed to service the various areas, these will be accessed by active click boxes in the areas served. The click box will not be positioned where the plant is located
- The floor plan overview will show the current values of any field mounted sensors. If the floor plans are too large to be easily shown on one screen, then multiple screens will be used. The terminal temperatures in each office or core area are to be displayed in the appropriate space on the floor plan.

Movement Between the Graphics

Each graphic will have click boxes to allow logical movement within the system. Every graphic will allow access to be gained to the overview graphic, associated air handling systems, return to previous and the home page.

Large systems that require multiple graphics will also have click boxes to route to the next part of the system.

Data Display

Wherever possible information is to be provided by means of colour change. All devices in their normal off state are to be orange. All devices in their normal on state are to be green. All devices in an alarm state are to be red. Wherever possible the command and feedback status are to be linked on the screen. For instance, a fan/ that is shown graphically as a triangle within a circle will be dynamically activated as follows.

The triangle will represent the command with the remainder of the circle indicating the feedback.

Overview graphic

The BMS graphics as well as including all plant and equipment shall be provided with one overall graphic that displays the status of every plant item. This graphic may be a text based system with red, amber, green indication for each system the system shall include all central plant systems. Jump tags shall be provided for each system allowing the user to immediately access the appropriate graphic.

Energy meter graphic

The BMS graphics shall include an energy metering displays grouped together on a system by system basis.

- Each AHU graphics shall include the meter display for the Ventilation and the air source heat pump.
- Each floor graphic shall show the tenant distribution board electrical meter and the air source heat pump electrical meter.
- Each floor graphic shall show the instantaneous energy being used by the ventilation plant serving from.
- Energy used on a floor by floor tenant can be compared on the same graphic.
- Electrical meter shall be shown in LV schematic arrangement.

Alarm Indications

Whenever an alarm occurs and wherever the user is within the graphical system a clear banner shall be displayed on top of any current display. Jump tags shall be provided from this alarm display to the appropriate graphic.

Specific Graphic Displays

The configuration of proprietary Building management System head end supervisors are each slightly different and it is recognised that each may have particular operations peculiar to itself. The following set out the minimum requirement from each system, further standard enhancements that are available will not be disabled even if they are not described below.

Each plant item will be displayed on a separate graphic. The graphic display will be as clean as possible and indicate only the current plant status such as:

- Drive status – on/off/fault

- Valve and damper status – open/closed/modulating position
- Sensor status – current values
- If the devices are currently under 'manual' command from the head end *via* an operator instruction this will be clearly indicated alongside the device; and
- Alarm reset button.

A text table at the bottom of the graphic will show the current desired status of the controlled devices.

- The reason that the plant is operating, this may include: Manual override from the head end, frost protection, warm up, cool down, occupied time, remote system demand, for
- Fixed set points such as air temperatures: which the system is attempting to achieve
- If set points are automatically adjusted by the operating software these set points will be indicated
- Any current system alarms
- If the device is a terminal unit such as a fan coil unit or fan powered mixing box, the primary air temperature serving the plant will be displayed.

An associated engineering table or pop up dialogue boxes will describe the following features and allow, with suitable passwords, the adjustment of the operating parameters:

- Systems comprising run and standby drives, the display will indicate the present lead drive
- Operator ability to change duty or prevent duty rotation, change the time and date of next rotation
- Drive run hours since last reset, maintenance run hour intervals, reset run hours to zero, adjust maintenance run hour intervals
- Operator ability to change between limits the system operating set points such as return air temperature, room air temperature, return air RH, room air RH
- It should be noted that it will not be possible to adjust, without changing the software coding such parameters as, air quality set point, maximum CO set point, maximum CO2 set point
- Operator ability to manually set valves and dampers to fixed positions
- Operator ability to set motor speed to a fixed value
- Operator ability to set motors to auto/manual state On or Off
- This operation merely bypasses the normal BMS demands, it will not negate any safety interlocks. If the plant is operating and 'manual off' is set the plant will shut down through its normal shut down routine. If the plant is off and the 'manual on' is set the plant starts through its normal start routine including opening necessary isolation valve and dampers
- If an optimiser is provided, operator adjustment of the optimiser set points. This will include the calendar and the set points to be achieved during the optimised period; and
- If the plant has a fixed time start/stop operator adjustment of the calendar.

Operator adjustments to the alarm set points, the routing of alarm messages, the alarm message, enable/disable the alarm block. This final function will be applicable to measured values only such as temperatures, humidity, and pressure. It will not be possible for the operator to disable alarm blocks from such items as motors or comms room equipment.

3.25 Controls Commissioning

The Automatic Controls specialist shall set to work the automatic control system as described within the project specification preliminaries and the minimum standards set out below.

The Contractor shall be responsible for the commissioning of all control's installation. It shall, however, be carried out by the Automatic Controls specialist, these shall include the BMS specialist, the AHU specialist and the VRF specialist.

On completion of the installation, the Automatic control specialist shall calibrate the system to the approval of the Client Representative.

The Automatic Controls specialist will allow for all costs in connection with the setting to work and commissioning of the complete control system. Commissioning will include trial operation of all moving parts, easing, fine adjustments, lubrication and the like carried out by the controls specialist to ensure that the works are in proper working order. The Automatic Controls specialist shall formulate and issue the test method statements indicating the testing to be carried out and the expected results. At the completion of any test, the Automatic Controls specialist shall issue the result sheets, signed and annotated with relevant comments.

The commissioning will also include the offsite testing of all software, starter and control panels.

The Automatic Controls specialist will include in his bid for all labour, special instruments, materials, tools, plant and equipment required to carry out the pre-commissioning and the performance testing of the control systems, all in accordance with the relevant CIBSE Commissioning Codes and this specification.

The Automatic Controls specialist will demonstrate to the complete satisfaction of the Client Representative that the installation or any portion thereof, which has been set to work, complies with the requirements of the specification.

Any defects of workmanship, materials, performance, maladjustment's, non-compliance with this specification, or other irregularities which become apparent during the tests will be rectified by the BMS specialist, at no additional cost to the contract, and the cost of the original test together with any repeat tests will be at the BMS specialist expense until the whole is proved free from defects and in complete working order to the complete satisfaction of the Client Representative. All systems will be left sound and correct.

After the above-mentioned conditions have been met in full and the system is fully operational, it shall be guaranteed for the defects liability period stated herein. Following each sectional completion of the works, the controls manufacturer shall allow for a minimum of four additional separate visits to site to check on continued satisfactory control performance.

Point to Graphic

The automatic control specialist shall check all field to graphic points and demonstrate 100% to the clients representative.

The package specialist shall include demonstration of pointer BMS graphic for 100% of the system.

Commissioning Requirements

The testing and commissioning shall be as described elsewhere in the specification and conform with the following requirements:-

The Contractor's responsibility for commissioning shall extend over the duration of the contract and defects liability period.

An outline of the tests required is given below, but, in any case, testing of the system must comply with relevant sections of BS ISO/IEC 6592:2000 Guideline for the documentation of computer based application systems.

The Automatic Controls specialist shall be responsible for inspecting and checking the complete electrical works associated with the automatic control installation by him or installed by others to his detailed requirements. The inspections shall include a check of power and control wiring; fuses, setting of timers or time clock controls; setting of transformer output voltages; fitting flexible electrical connections and provisions of earthing, bonding and screening, as necessary.

The Automatic Controls specialist shall advise the Client Representative of any site tests and give seven days' notice in writing of final tests so that they shall be carried out in the presence of the Client Representative or his representative.

The Automatic Controls specialist shall provide services of skilled commissioning engineers, certified test equipment, tools and instruments for any tests and make good any defects.

The Automatic Controls specialist shall test, calibrate, adjust, check and reset thermostatic and automatic controls and shall provide all test certificates and calibration charts.

The Automatic Controls specialist shall test all electrical equipment associated with the automatic controls installation and provide test certificates.

The Automatic Controls specialist shall check the operation of all alarms, safety devices and plant interlocking by simulating fault conditions.

During the defects, liability period the Automatic Controls specialist shall make several visits to the site and shall carry out thorough checks for continued satisfactory controls operation.

Such adjustments that are necessary to the controls installation under actual working conditions shall be made by the Automatic Controls specialist and reported to the Client Representative and shall take due account of variation due to occupancy of the building, seasonal changes or variations in the operation of mechanical plant under control etc.

Until the final check and adjustment has been carried out, the contract shall not be considered for final acceptance and the balance of retention sums shall not be released.

Installation Test Report

The Automatic Controls specialist shall provide detailed trend logging of the operation of the building services plant interfaced to the Automatic Controls. The Automatic Controls specialist shall co-ordinate with others and all other necessary suppliers to ensure that the complete building services operate in a homogenous state for a minimum of seven days.

During the seven day period, the Automatic Controls specialist shall arrange for step changes to be made to the plant to demonstrate that the Automatic Controls is able to recognise the change and react accordingly.

The Automatic Controls specialist shall provide sufficient hardware/software to allow every field and virtual point to be logged simultaneously for 24 hours at 1 minute intervals.

Details of Tests

Tests of the equipment prior to handover shall include the following minimum requirements.

Functional operation of all sensors, actuators, detectors and transducers to ensure correct and accurate measurement and operation; in accordance with the manufacturers specification for equipment supplied, and the relevant clauses of this document.

Demonstration of calibration procedures to ensure that all sensors and detectors operate within acceptable limits and with the specified accuracy.

Restart test to ensure that temporary mains failure or card removal does not cause degradation in system operation or loss of calibration in sensors and actuators.

Failsafe and override checks to demonstrate that all facilities operate as specified.

Checks on system performance relating to the ability to call up logs, alarm reports etc., and likewise to make corrections to switching times, set points, interlocks and other facilities accessible from the keyboard, all as detailed in the Contract.

The production of ‘dummy run’ management reports, data analysis, exception reports and operational messages.

The production of dummy run tenant bills for all aspects of the project.

The production of ‘dummy run’ alarm messages and a demonstration of the correct routing and application of these messages to the dedicated line printers.

Deliberate introduction of faults, by agreement, shall demonstrate the system’s ability of self-analysis and alarm condition reporting, as well as the self-diagnostic ability of the system.

The energy meters shall be confirmed as a 100% test from field to database/graphic for identification and values. The tests shall be carried out twice at least 2 weeks apart to confirm reliability and accuracy of the readings.

The Automatic Controls specialist shall provide a detailed test plan prior to commencing the works. The testing shall include but not be limited to such items as:

- Optimised start.
- General operation of packaged air handling plants
- Operation of fan coil units
- Operation of air source heat pumps
- Operation of DX heating/cooling units
- Cooling operation loading and unloading.
- Heating operation loading and unloading.

- Building frost protection.
- Individual fan failures.
- Inverter faults.
- Failures of the air source heat pumps.
- Power failures to individual MCCs and mechanical service power boards.
- Power failures to individual remote outstations.
- Failed temperature, pressure and humidity sensors.
- Disconnection of network at individual CEs.
- Manual plant operation from the head end.
- Issuing of emails during fault conditions.
- Fire cause and effect.

The operation of the plant and its ability to react shall be recorded by the Automatic Controls specialist, both as a hand record of the events and a full Automatic Controls log. The logs shall show system set points and the actual values achieved.

The Automatic Controls specialist shall review the test results; annotate the reports indicating the faults that occurred, the records obtained by the Automatic Controls and the system reactions. The reports shall be reviewed, BMS specialist modified and the systems corrected where incorrect actions are noted. The testing shall continue with full recording for a minimum of seven days and until the works are fault free.

The trend logs shall show plant operation over the entire period with all field and virtual points logged at a minimum of one-minute intervals.

Installation Test Report

The Automatic Controls specialist shall provide detailed trend logging of the operation of the building services plant interfaced to the Automatic Controls system. The Contractors shall co-ordinate with others and all other necessary suppliers to ensure that the complete building services operate in a homogenous state for a minimum of seven days.

During the seven day period, the Automatic Controls specialist shall arrange for step changes to be made to the plant to demonstrate that the BMS is able to recognise the change and react accordingly.

Environmental Report

The Building Services Contractors shall arrange for a survey in all office areas of temperatures that are being achieved after the system has been fully adjusted and ready for occupation.

The survey shall monitor room / circulation air temperature for a period of 7 days. The survey shall include

- The monitoring of plant start/stop times
- The monitoring of general floor space temperature.
- The monitoring of return air set point and achieved temperature to four coil units in each tenant demise

- The record of all plant running - includes FCUs, AHUs, HWS system
- A record of the electrical power consumed
- Morning boost operation
- low space temperature protection
- HWS temperature
- AHU start/stop times
- AHU supply and return air temperatures.

The survey shall include the demonstration of plant loading and unloading. Appropriate commissioning Contractor attendance shall be provided to manually adjust the system where necessary to simulate load variance and to validate controls calibration for flow measurement and differential pressure.

The data may be recorded either by the BMS sensors, the AHU sensors and all the FCU sensors it is not necessary to provide additional sensors.

Handover Procedure

The handover procedure shall be as defined in the contract terms and conditions. In addition, the contractors shall demonstrate the BMS plant operation both as a single entity and as a homogenous installation with the MEP services. The contractors shall develop the handover procedure that will demonstrate a number of specific activities. The reports shall demonstrate that the plant and equipment has been installed and any defects closed out or agreed with the client with suitable procedure for rectification and that the plant and equipment is operating as intended. This shall include but is not limited to the following:

- An installation report that identifies that the plant/equipment has been installed to the manufacturer's recommendations, is labelled and installed in a neat and workmanlike manner
- An installation report that identifies that the plant and equipment has been inspected by the main contractor and is confirmed by them as being suitable for acceptance of the client
- An inspection report that confirms that each plant item has been demonstrated as operating against the agreed operation procedure and that all safety interlocks have been tested to a satisfactory standard
- The environmental report, with comments and advice for future enhancement of the plant operation
- A testing report that confirms that each instrument and actuator has been demonstrated as being calibrated and reporting correct information to the BMS display panel
- The report shall confirm that local operators have been trained in what to expect for the plant operation, how and where the safety interlocks are provided and what user information and adjustments can be made
- The building logbook should be provided.

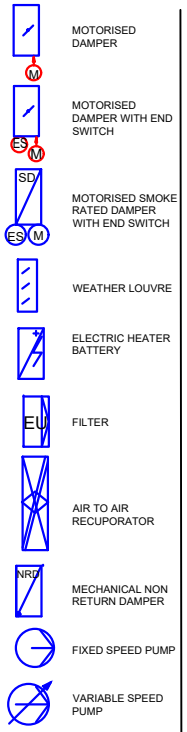
The operating and maintenance manuals should be provided. Where necessary the base build manuals shall be modified to reflect the new works.

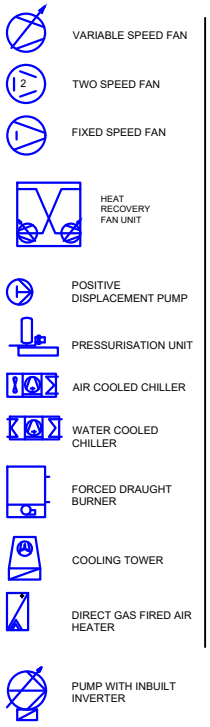
APPENDICES

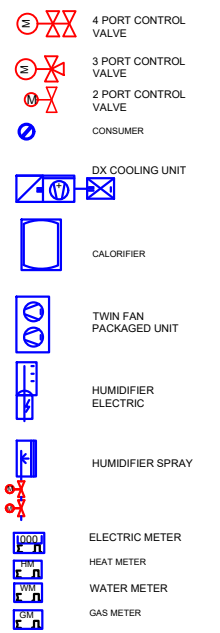
A. AUTOMATIC CONTROLS POINTS DRAWINGS

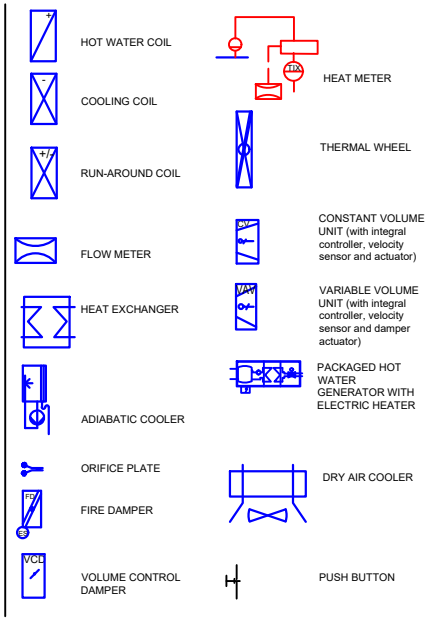
FAIRLAWN CONTROLS

OCT 2022



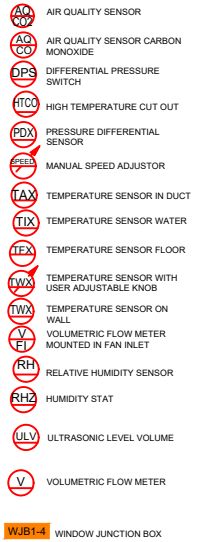


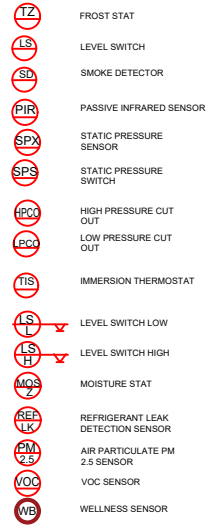




ALM - EQUIPMENT MONITORING POINT
BRT - BOILER RESET TEMPERATURE
BFR- BOILER FIRING RATE
CBO - COMMAND BOILER ON /OFF
CCO - COMMAND CONTACTOR ON /OFF
CCR - RUN STATUS OF CHILLER
CDM - COMMAND DAMPER MODULATING
CDO - COMMAND DAMPER TWO POSITION
CEO - COMMAND EQUIPMENT ON/OFF
CFO - COMMAND FAN ON/OFF (HS- HIGH SPEED, LS-LOW SPEED)
CFIO - COMMAND FAN INVERTER ON /OFF
CHM - COMMAND HEATER MODULATION
CHUM - COMMAND HUMIDIFIER MODULATION
CHO - COMMAND HEATER ON /OFF
CHUO - COMMAND HUMIDIFIER ON /OFF
CIO - COMMAND INVERTER ON/OFF
CP - CONTROL PANEL
CPO - COMMAND PUMP ON / OFF
CPIO - COMMAND PUMP INVERTER ON / OFF
CVM - CONTROL VALVE MODULATION
CVO - CONTROL VALVE OPEN/CLOSE
CVP - CONTROL VALVE POSITION
DA - DRIVE AVAILABLE
DXCLG - DX COOLING STAGE
EHM - ELECTRIC HEATER MODULATION
EHO - ELECTRIC HEATER ON/OFF
ES - END SWITCH STATUS (D-DAMPER, V-VALVE)
FIR - FIRE ALARM
FIE - FIREMAN'S EXTRACT SWITCH
FIFS - FAN INVERTER FAULT STATUS
FIRS - FAN INVERTER RUN STATUS
FLS - GENERAL FLOW STATUS

FLT - GENERAL FAULT STATUS
FPS - FILTER PRESSURE SWITCH
FSC - INVERTED FAN SPEED CONTROL
FSM - FAN SPEED MODULATION
FRS - FAN RUN STATUS - (HS - HIGH SPEED, LS - LOW SPEED)
HPCO - HIGH PRESSURE CUT OUT
HUM - HUMIDIFIER MODULATION
HUF - HUMIDIFIER FAULT
IRS - INVERTER RUN STATUS
LPCO - LOW PRESSURE CUTOUT
LTCO - LOW TEMPERATURE CUTOUT
PIFS - PUMP INVERTER FAULT STATUS
PRS - PUMP RUN STATUS
PSM - PUMP SPEED MODULATION
PWR - MOTOR POWER KWHR
SAFETY - HARDWIRED SAFETY INTERLOCKS
STS - GENERAL PLANT STATUS
SWT - SWITCH STATUS
SW - SOFTWARE INTERFACE
TWSM - THERMAL WHEEL SPEED MODULATION
TI - FIELD POINT WIRED TO INVERTER TERMINALS
TIX - IMMERSION TEMPERATURE SENSOR
TH - THERMISTOR SENSOR WIRING
TRS - TEMPERATURE ADJUSTMENT
TWX - SPACE TEMPERATURE SENSOR
TZ - FROST STAT TRIP
VOL - VOLUMETRIC FLOW RATE
VRST - VOLUMETRIC FLOW RATE RESET





1. ON LOAD LOCKABLE ISOLATOR
2. MCB TYPE C OR D RATED IN ACCORDANCE WITH DRIVE AND STARTING METHOD
3. FUSE PROTECTION
4. 3-PHASE HEALTHY LAMPS
5. MID APPROVED - KILOWATT HOUR METER WITH INSTANTANEOUS AND ACCUMULATIVE READ OUT. AMPS AND VOLTS PER PHASE USING SOFT KEYS. (M-BUS/MODBUS/BACNET OUTPUT)
6. NON DOOR INTERLOCKED ISOLATOR
7. STAR DELTA STARTER WITH HAND RESET THERMAL OVERLOADS
8. INVERTER DRIVE
9. CONTACTOR
10. EC MOTOR DRIVE
11. MOTOR PHASE ANGLE SHIFT RELAY
12. CONTACTOR RESET
13. DISTRIBUTION BOARD WITH MCBS FOR REMOTE PACKAGED EQUIPMENT
14. RELAY SECTION
15. TERMINAL SECTION FOR DRIVES
16. KWHR METER
17. CONTROLS TRANSFORMER
18. PUMP (FAN) 1/ PUMP (FAN) 2 SELECTOR SWITCH
19. HAND/OFF/AUTO SWITCH - (SYSTEM)
20. HAND/OFF/AUTO SWITCH - (INDIVIDUAL DRIVE)
21. OFF/AUTO SWITCH
22. RUN LAMP 'GREEN' (DRIVEN FROM BMS)
23. TRIP LAMP 'AMBER'
24. SYSTEM RUNNING LAMP 'GREEN'
25. HTCO LAMP
26. CHILLER HAND/OFF/AUTO SWITCH
27. PRESSURISATION UNIT FAULT LAMP 'AMBER'
28. RUN LAMP 'GREEN' derived from DPS OR inverter run signal
29. TRIP LAMP 'AMBER' derived from packaged plant starter
30. THYRISTOR
31. HUMIDIFIER OFF/AUTO SWITCH
32. FAULT
33. GAS VALVE 'CLOSED' LAMP (AMBER)
34. GAS VALVE 'RESET' PUSH BUTTON
35. BOILER FIRING
40. AUTOMATIC POWER TRANSFER SWITCH WITH MANUAL BYPASS
41. MAINS 1 AVAILABLE LAMP 'WHITE'
42. MAINS 2 AVAILABLE 'WHITE'
43. MAINS 1 SELECTED 'WHITE'
44. MAINS 2 SELECTED ' WHITE'
45. CONTROL CIRCUIT HEALTHY 'WHITE'
46. FIRE ACTIVE 'AMBER'
47. BMS (PLC) OUTSTATION
48. BMS (PLC) KEY/DISPLAY PANEL ON PANEL FASCIA
49. ALARM RESET BUTTON
50. LOW PRESSURE
51. SYSTEM COMMON ALARM LAMP 'AMBER'
52. GAS UPS
53. BMS (PLC) UPS
54. CONDENSER UNIT OFF/AUTO SWITCH
55. ANTI CONDENSATION HEATER AND THERMOSTAT
56. PUSH TO START BUTTON
57. PUSH TO STOP BUTTON
58. LAMP GROUP TEST BUTTON
59. INTERNAL PANEL LAMP
60. TANKA/TANKB/COMMON SELECTOR SWITCH
61. HARDWIRED TIMER TO HOLD GAS SYSTEM HEALTHY
62. AUTO/LOW SPEED/HIGH SPEED SWITCH WITH HARDWIRED TIMER FOR HIGH TO LOW SPEED
63. CO HIGH LEVEL INDICATION
64. FIREMANS OVERRIDE KEY SWITCH - AUTO/OFF/HIGH SPEED
65. MAINTENANCE SWITCH ON/OFF
66. FIRE ALARM TEST SWITCH
67. SOFT START
68. METER GATEWAY - MODBUS/M-BUS TO BACNET
69. WALL MOUNTED KEYPAD/DISPLAY PANEL ALLOWING ACCESS AS A BROWSER TO THE LOCAL AHU/FAN TILES
70. KEYPAD/DISPLAY PANEL ALLOWING SITE WIDE ACCESS AS A BROWSER TO THE COMPLETE BMS
71. LAYER 2 MANAGED SWITCH
72. RJ 45 FOR COMMISSIONING PORT
73. CLASS 2 SURGE ARRESTOR

LOCKABLE ON LOAD ISOLATOR
KEY RELEASE LOCK STOP BUTTON
TWIST TO RELEASE LOCK STOP BUTTON
8 INVERTER WITH ISOLATOR
PSACO PACKAGED STARTER PANEL WITH INTEGRAL AUTOCHANGE OVER
PSMP PACKAGED STARTER PANEL WITH INTEGRAL MOTOR PROTECTION

SERVICES PROVIDED BY THE BMS SPECIALIST
SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By

Amendments

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS
LEGEND

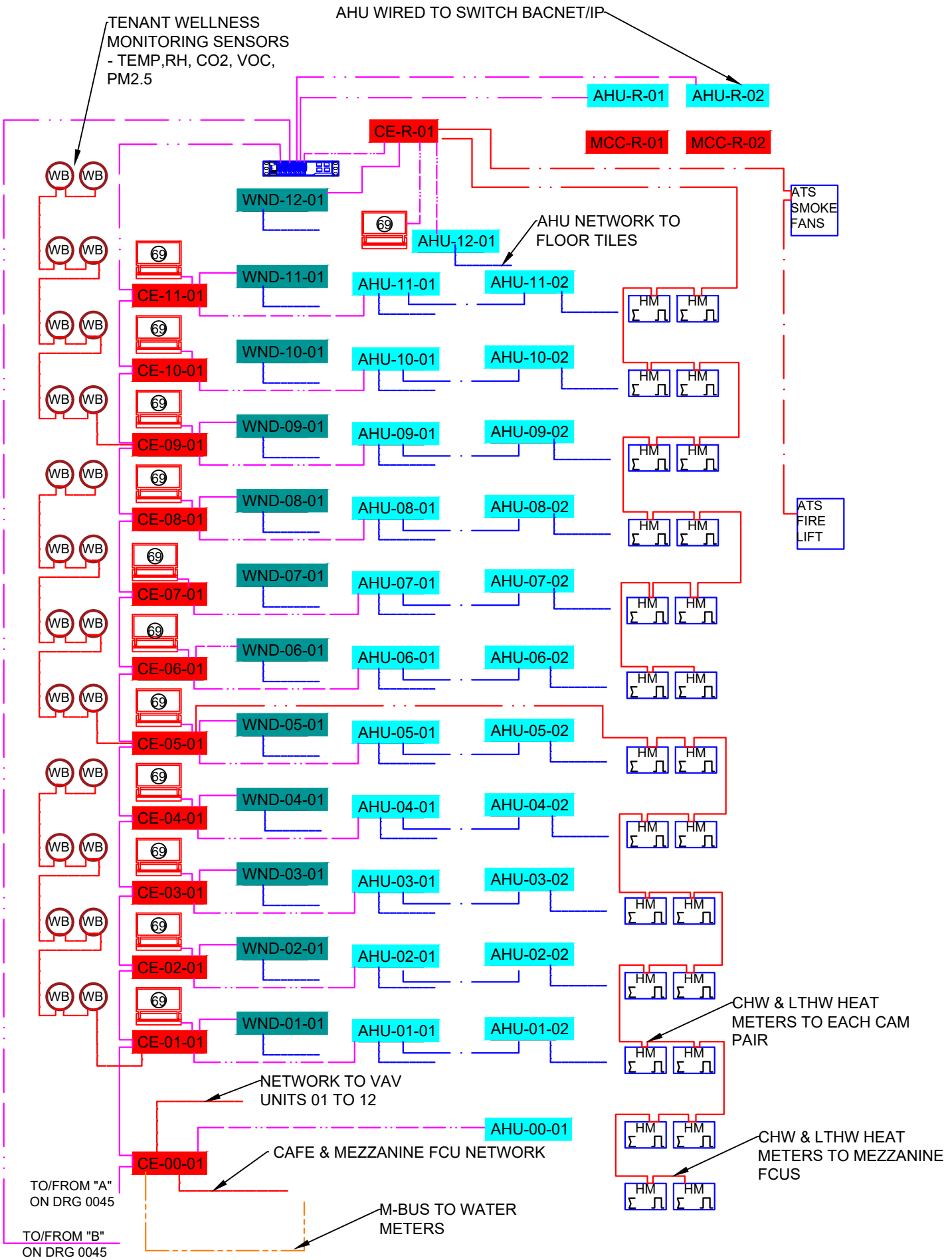
Client:

Drawing Status:

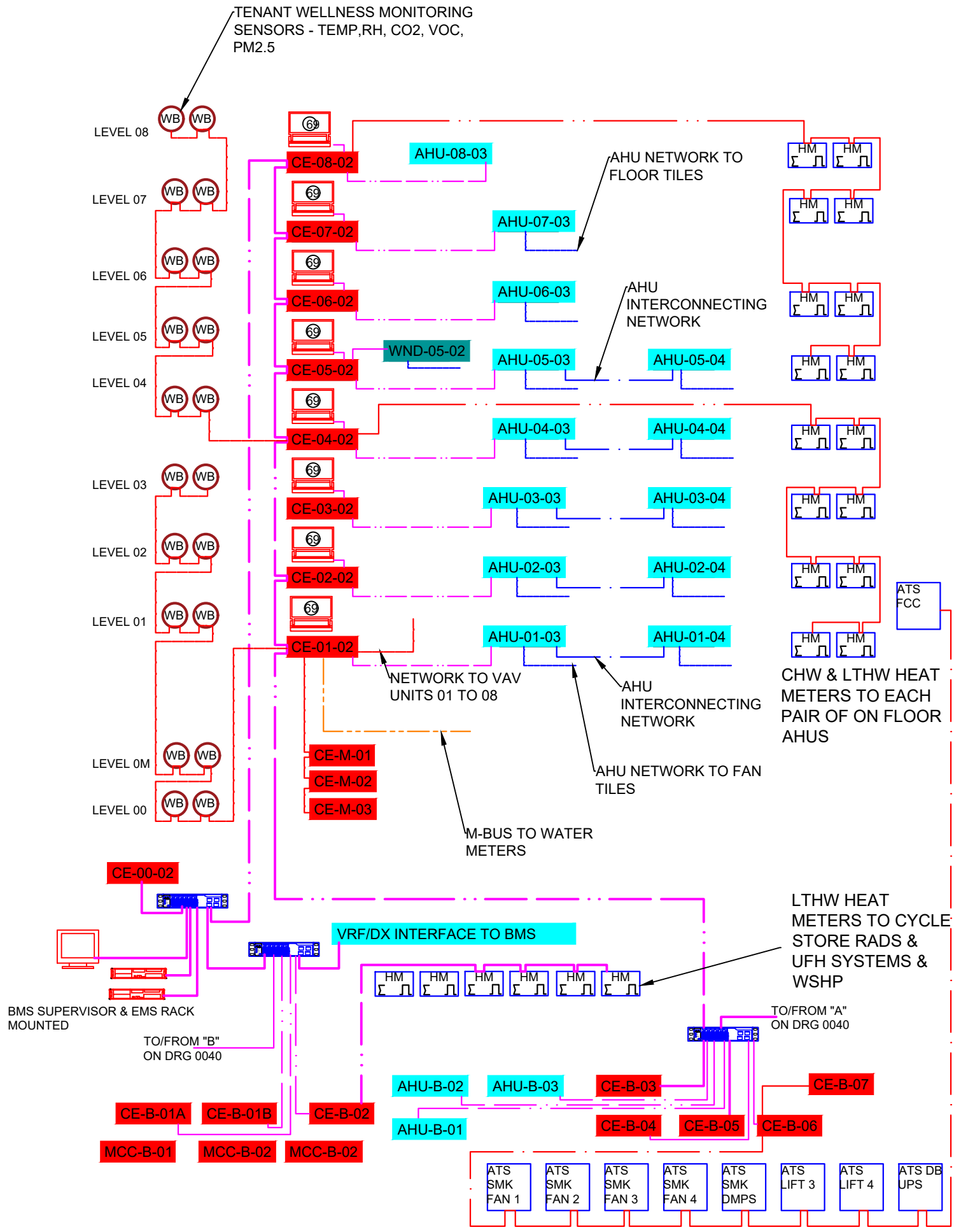
Designed by: Alan Jones
Designed by:
Project no.:
Drawn by: Alan Jones
Date: 10-10-2021
Scales @ A3
Work to figured dimensions only
Computer file No.:

Project - Originator - Volume- level - Type - Role - Number: 0010

Revision: C-01



	Project: OCT 2022	Drawing Status: RIBA stage 4 (i)	
	Title: AUTOMATIC CONTROLS NETWORK	Designed by: Alan Jones; Designed by: ; Project no.:	
		Drawn by: Alan Jones; Date: 21-10-21	
		Scales @ A3; Work to figured dimensions only; Computer file No.	
	Client:	Project-Originator-Volume-Level-Type-Role-Number: 0040	Revision: C-01
AMENDMENTS			



		Project: OCT 2022	Drawing Status: RIBA stage 4 (i)
		Title: AUTOMATIC CONTROLS NETWORK 2	Designed by: Alan Jones; Drawn by: Alan Jones; Date: 21-10-21; Scales @ A3; Work to figured dimensions only; Project no.; Computer file No.
AMENDMENTS		Client	Project-Originator-Volume-Level-Type-Role-Number: 0045; Revision: C-01

BASEMENT

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

PRINT IN COLOUR | GENERAL NOTES

Rev	Date	Description	By
		Amendments	

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

PANEL LOCATION
LEVEL BASEMENT

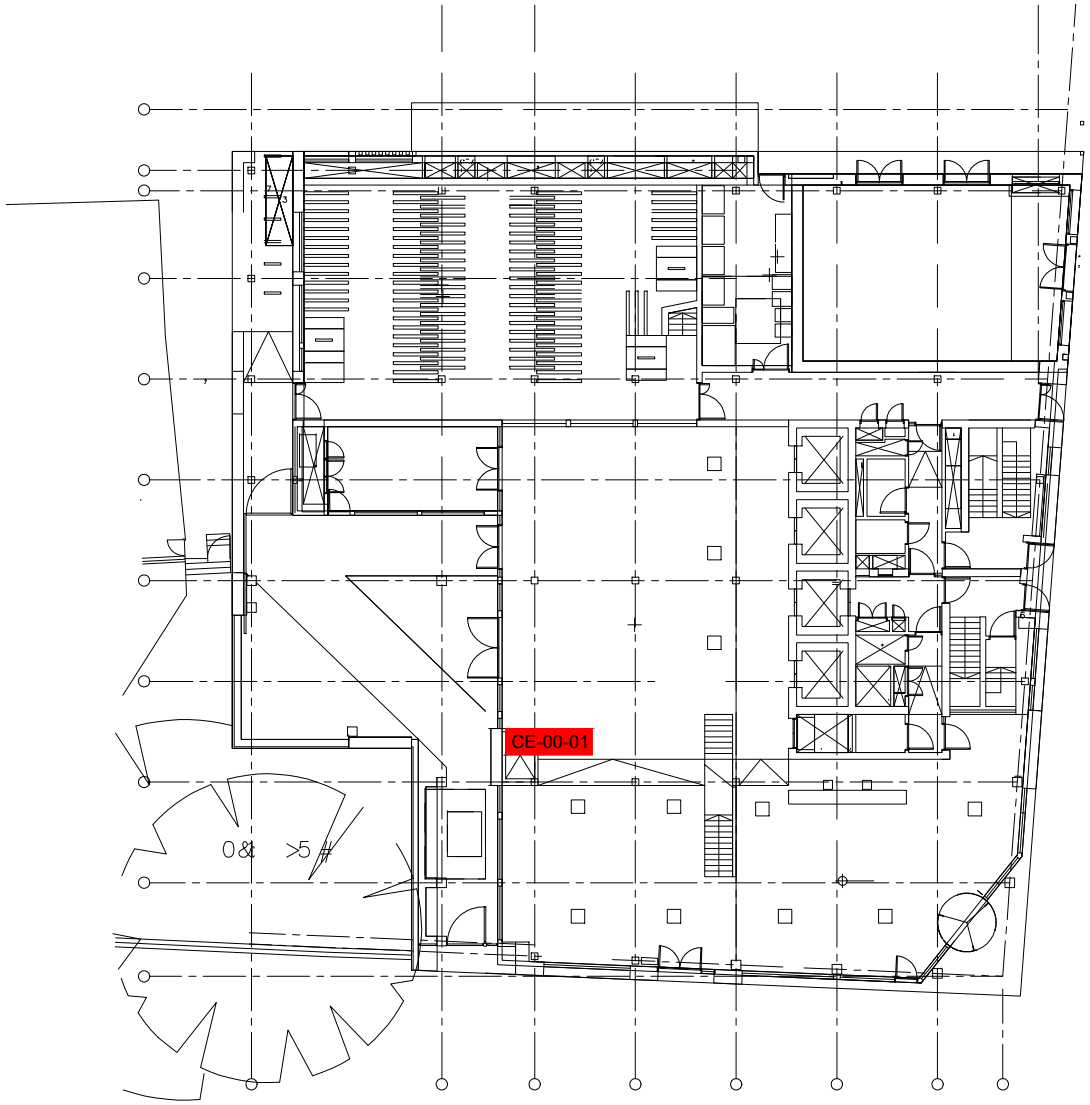
Client:

Drawing Status:

Designed by: Alan Jones
Designed by:
Project no.:
Drawn by: Alan Jones
Date: 10-10-2021
Scales @ A3
Work to figured dimensions only
Computer file No.:

Project - Originator - Volume- level - Type - Role - Number: 0050

Revision: C-01



GROUND

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

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FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

PANEL LOCATION
LEVEL 00

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

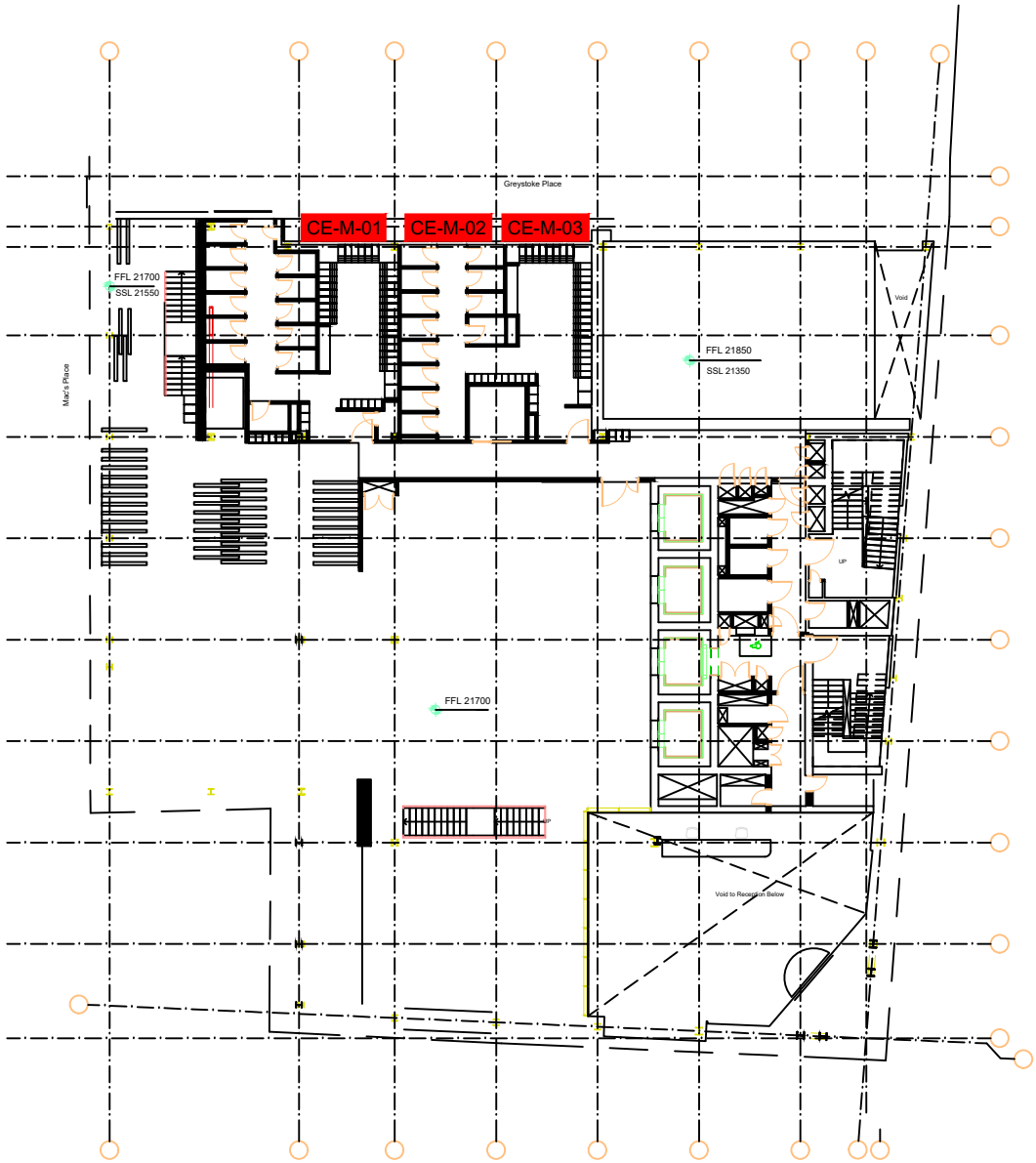
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 0055

Revision: C-01



MEZZANINE LEVEL

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

PANEL LOCATION
LEVEL MEZZANINE

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Drawn by: Alan Jones

Date: 10-10-2021

Project no.

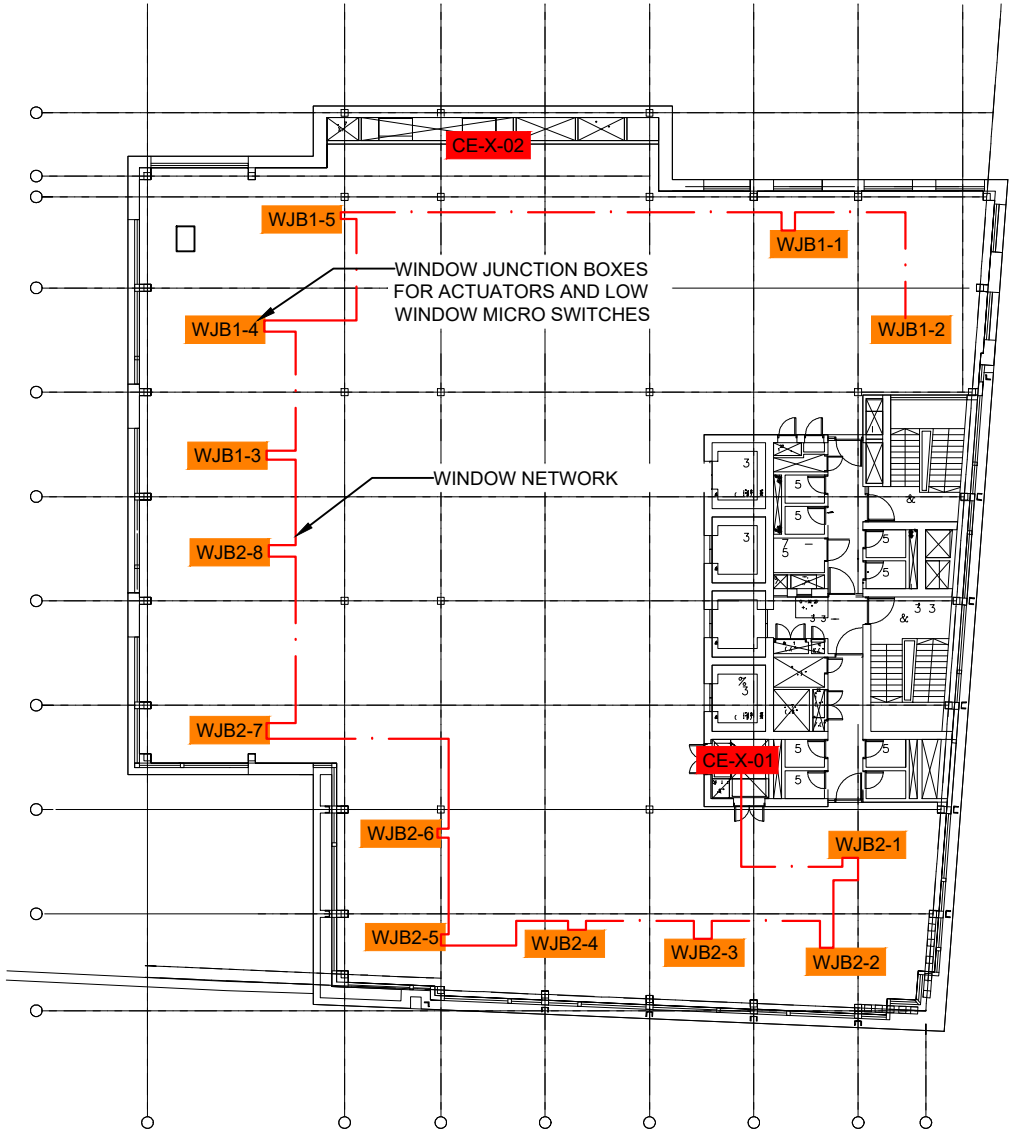
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 0060

Revision: C-01



LEVELS 01 TO 06

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

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FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

PANEL LOCATION
LEVEL 01 TO 06

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 0065

Revision: C-01

LEVELS 07, 08

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

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FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

PANEL LOCATION
LEVEL 07, 08

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 0070

Revision: C-01

LEVELS 09, 10, 11

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

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FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

PANEL LOCATION
LEVEL 09, 10,11

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Drawn by: Alan Jones

Date: 10-10-2021

Project no.

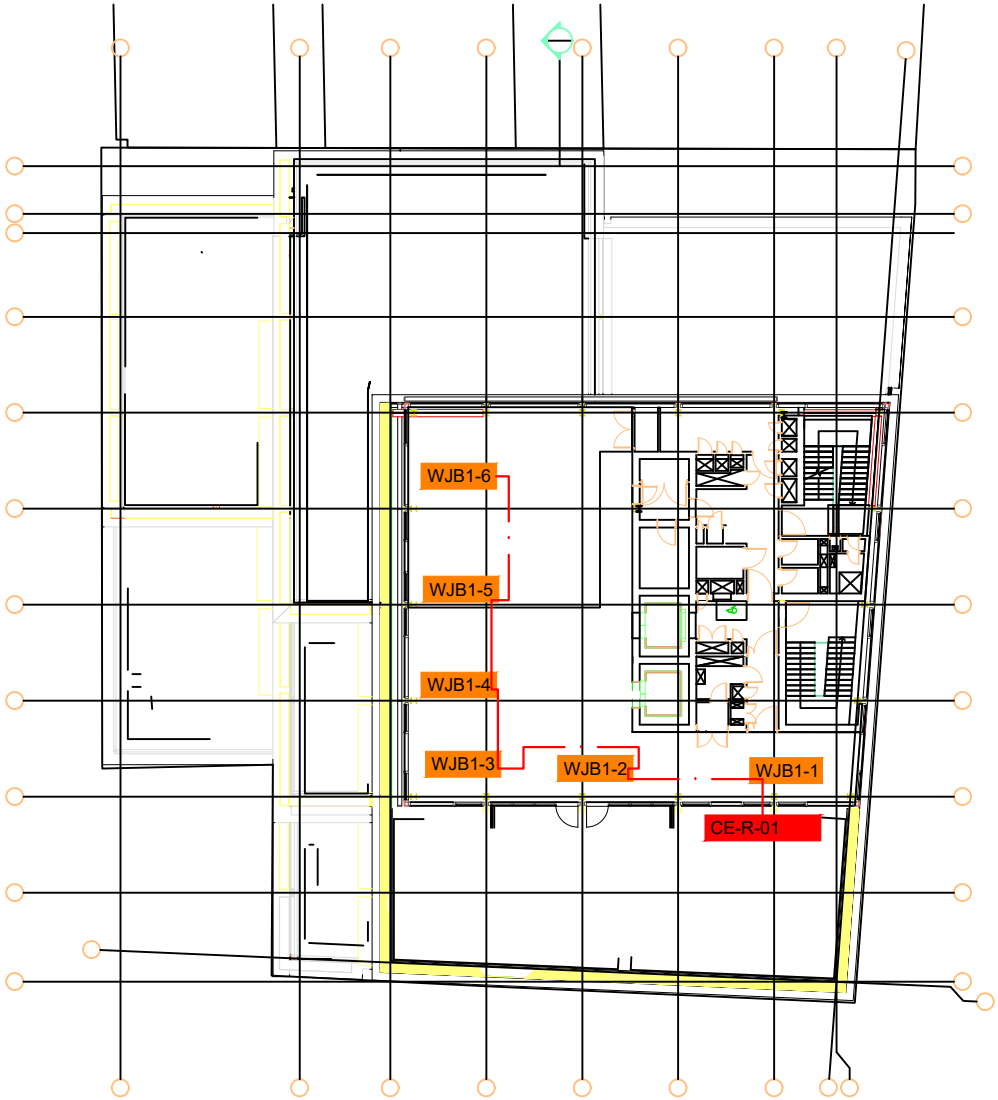
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 0075

Revision: C-01



LEVEL 12 OFFICE

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

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Rev	Date	Description	By
		Amendments	

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

PANEL LOCATION
LEVEL 12

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

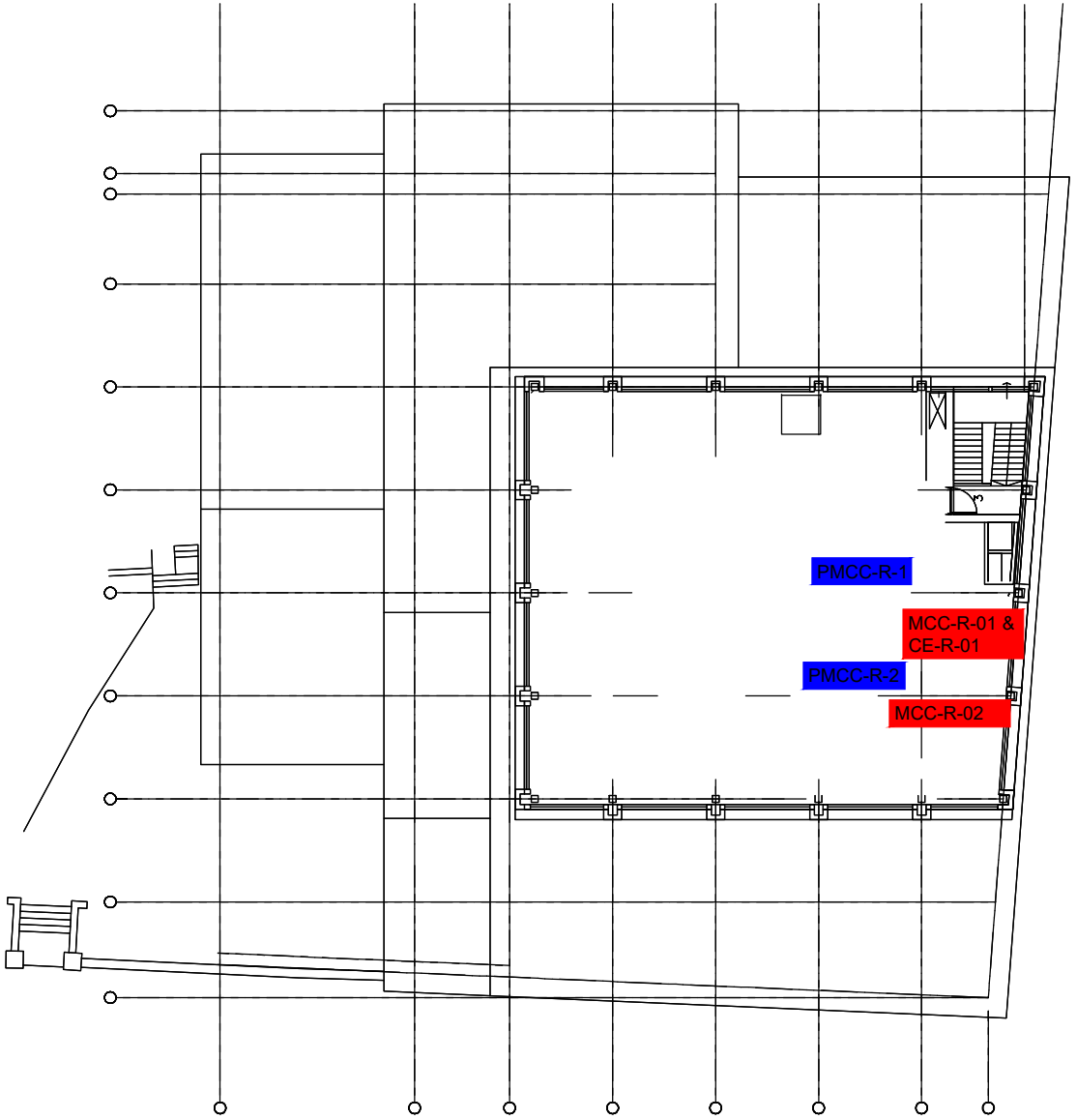
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 0080

Revision: C-01



LEVELS ROOF

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

PRINT IN COLOUR | GENERAL NOTES

Rev	Date	Description	By

Amendments

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

PANEL LOCATION
LEVEL ROOF

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

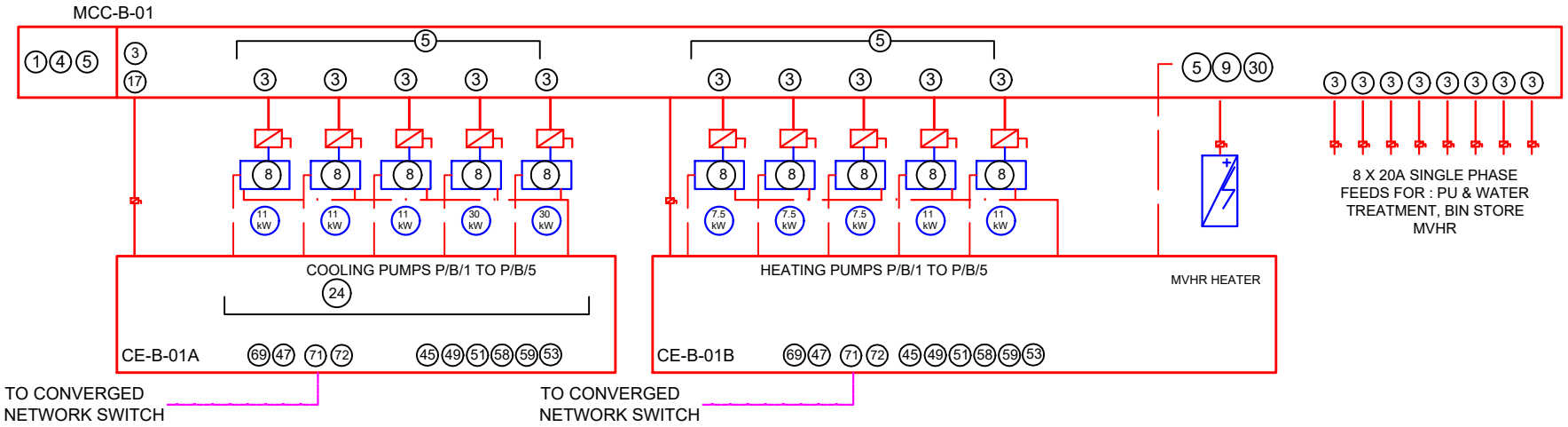
Scales @ A3

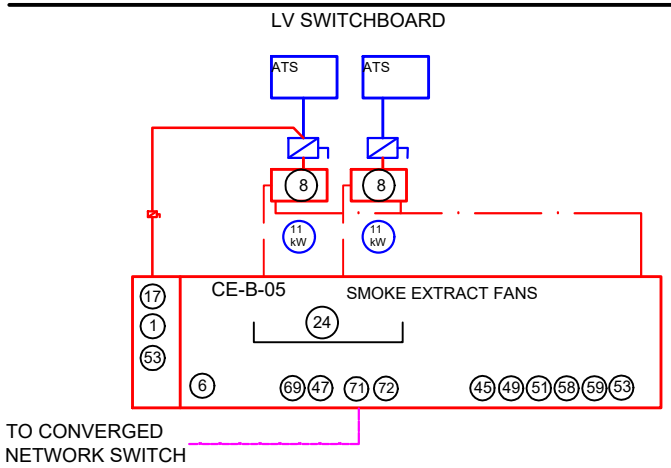
Work to figured dimensions only

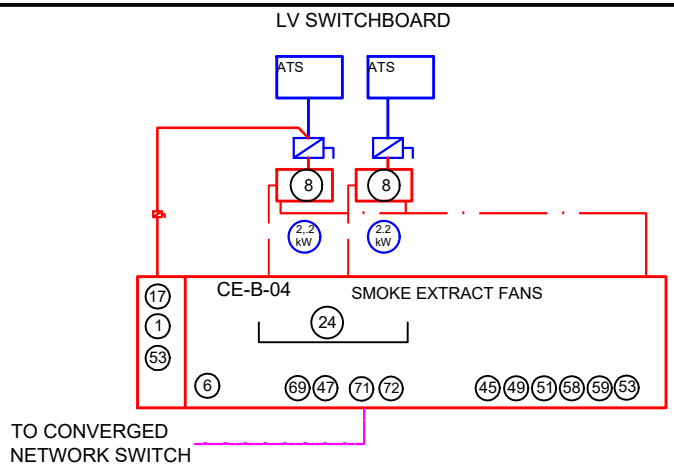
Computer file No.

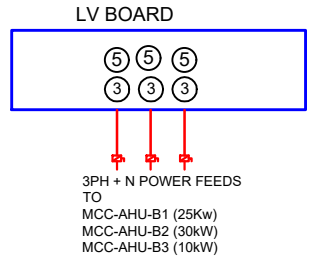
Project - Originator - Volume- level - Type - Role - Number: 0085

Revision: C-01









SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

CONTROL PANEL 1

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

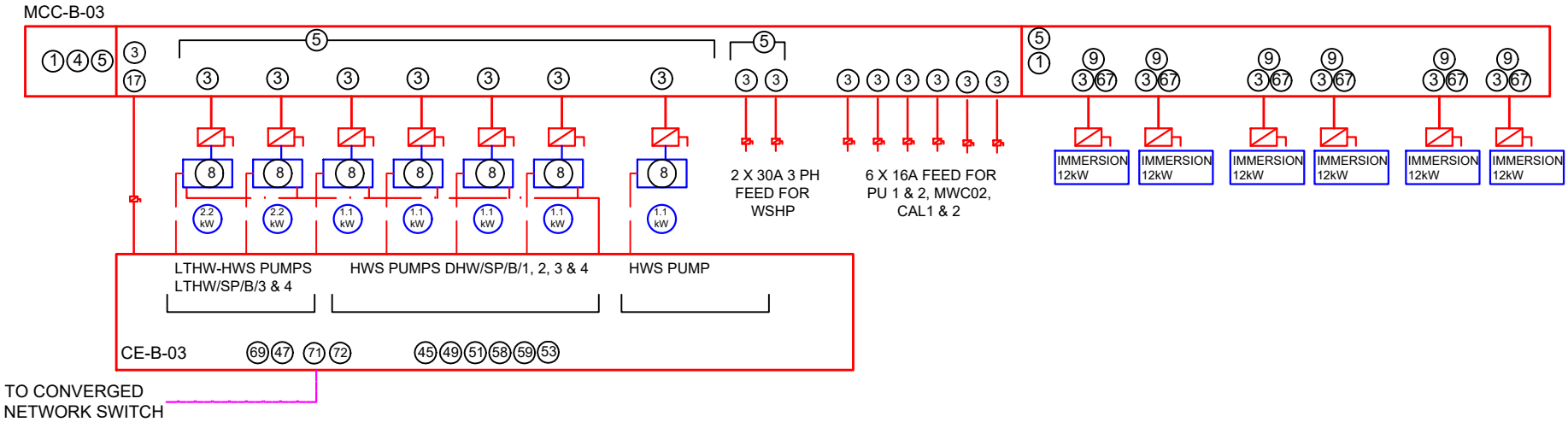
Scales @ A3

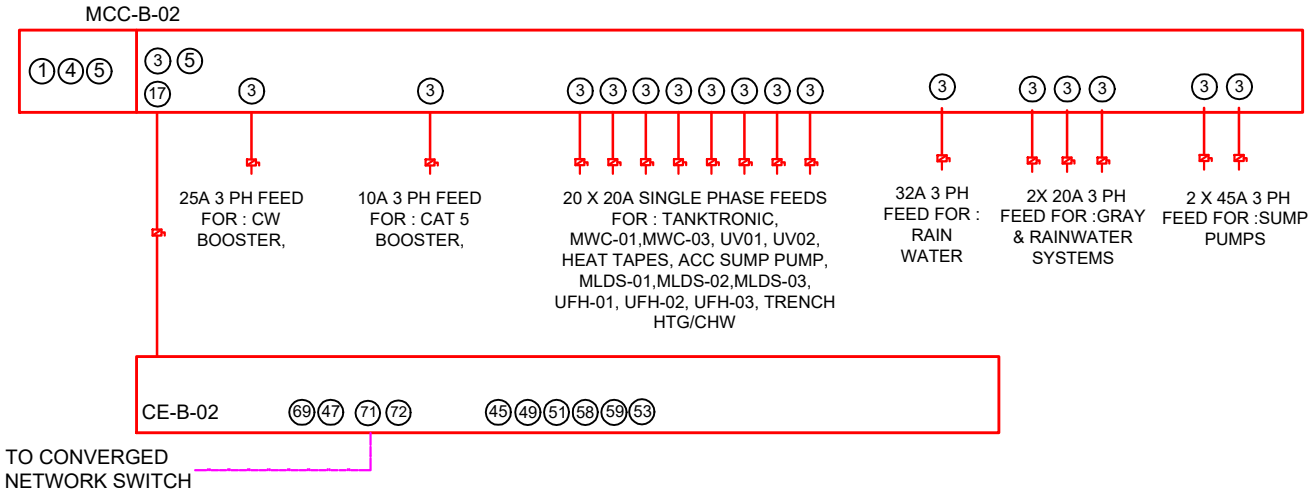
Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 0100

Revision: C-01





SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By

Amendments

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

CONTROL PANEL 5

Client

Drawing Status

Designed by: Alan Jones | Designed by | Project no.

Drawn by: Alan Jones | Date: 10-10-2021

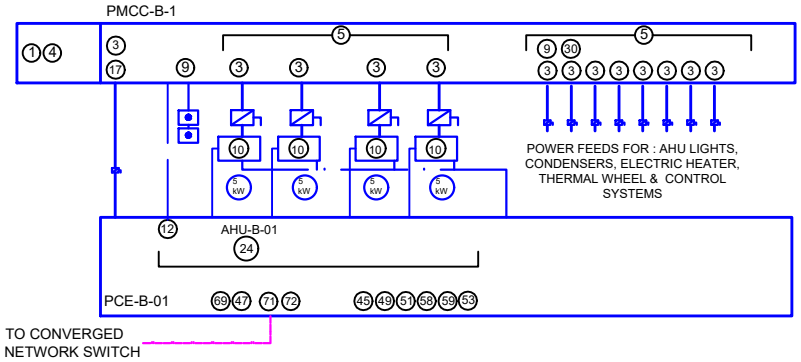
Scales @ A3

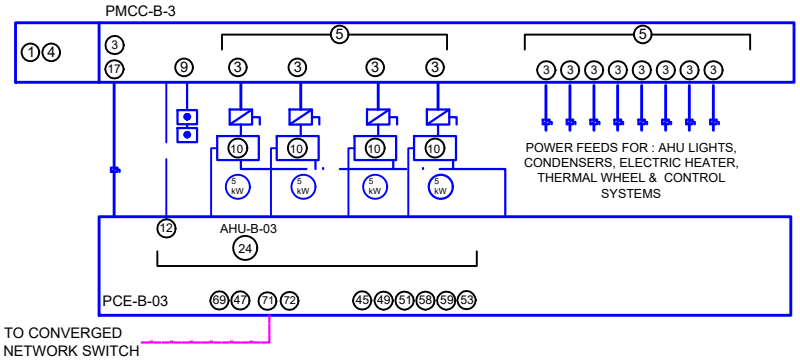
Work to figured dimensions only

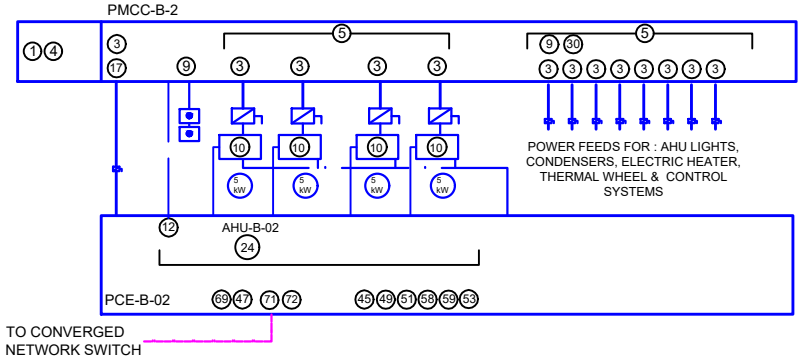
Computer file No.

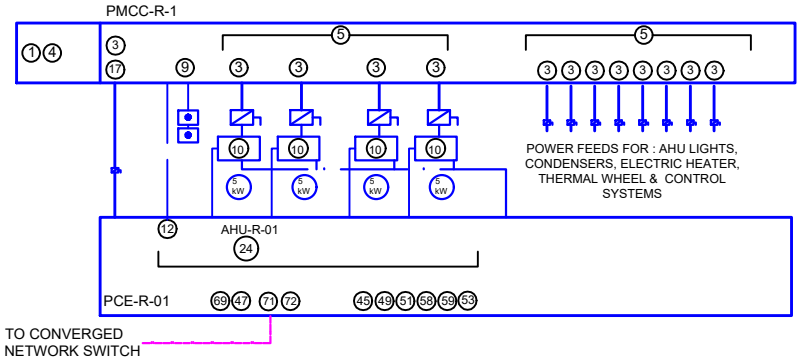
Project - Originator - Volume- level - Type - Role - Number: 0105

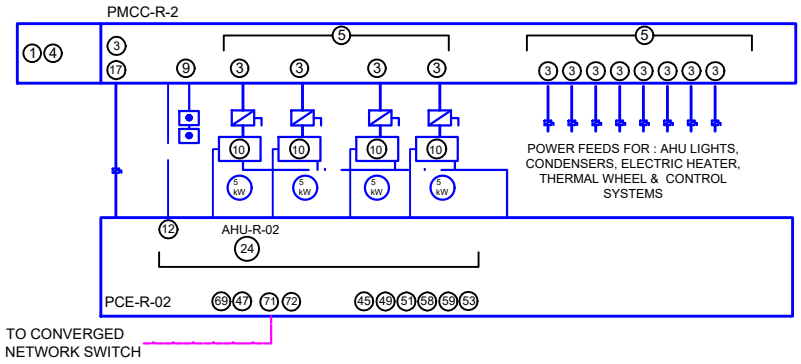
Revision: C-01











SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

CONTROL PANEL 2

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

Scales @ A3

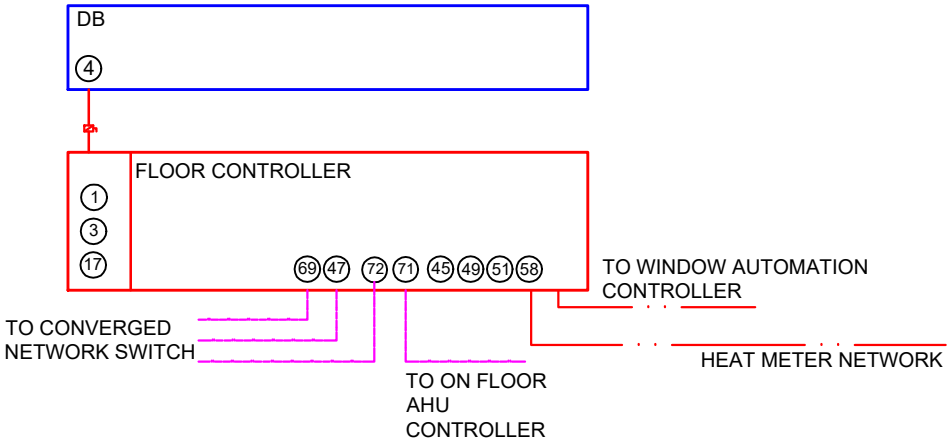
Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number

0110

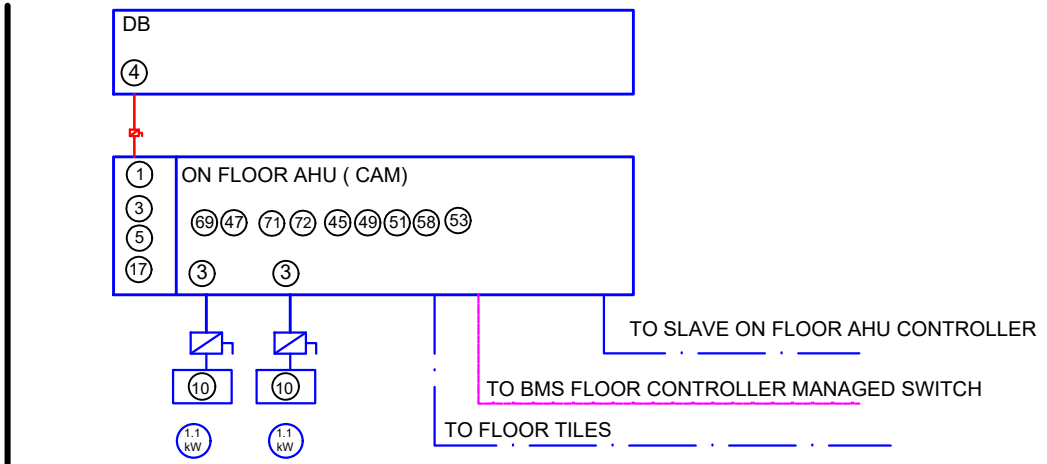
Revision: C-01



CE-00-01
CE-01-01 TO CE-11-01
CE-01-02 TO CE-08-02

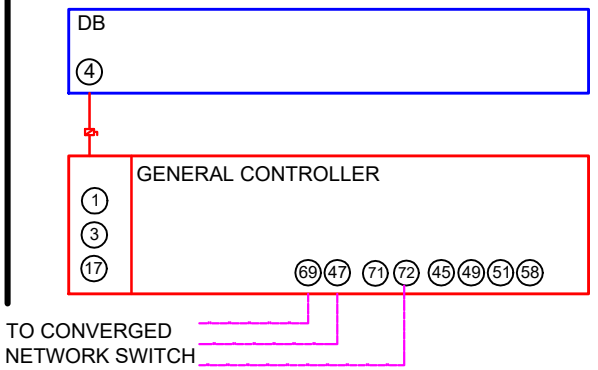
THESE PANELS PROVIDE POWER TO THE VAV UNITS, THE WELL BEING SENSORS & THE HEAT METERS

BMS TENANT FLOOR PANELS



PMCC-00-01
PMCC-01-01 TO PMCC-11-01
PMCC-01-02 TO PMCC-11-02
PMCC-01-03 TO PMCC-08-03
PMCC-01-04 TO PMCC-05-04

ON FLOOR AHU (CAM) PANELS



BMS PANEL

CE-B-06
CE-B-07
CE-M-01
CE-M-02
CE-M-03

SERVICES PROVIDED BY THE BMS SPECIALIST
SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

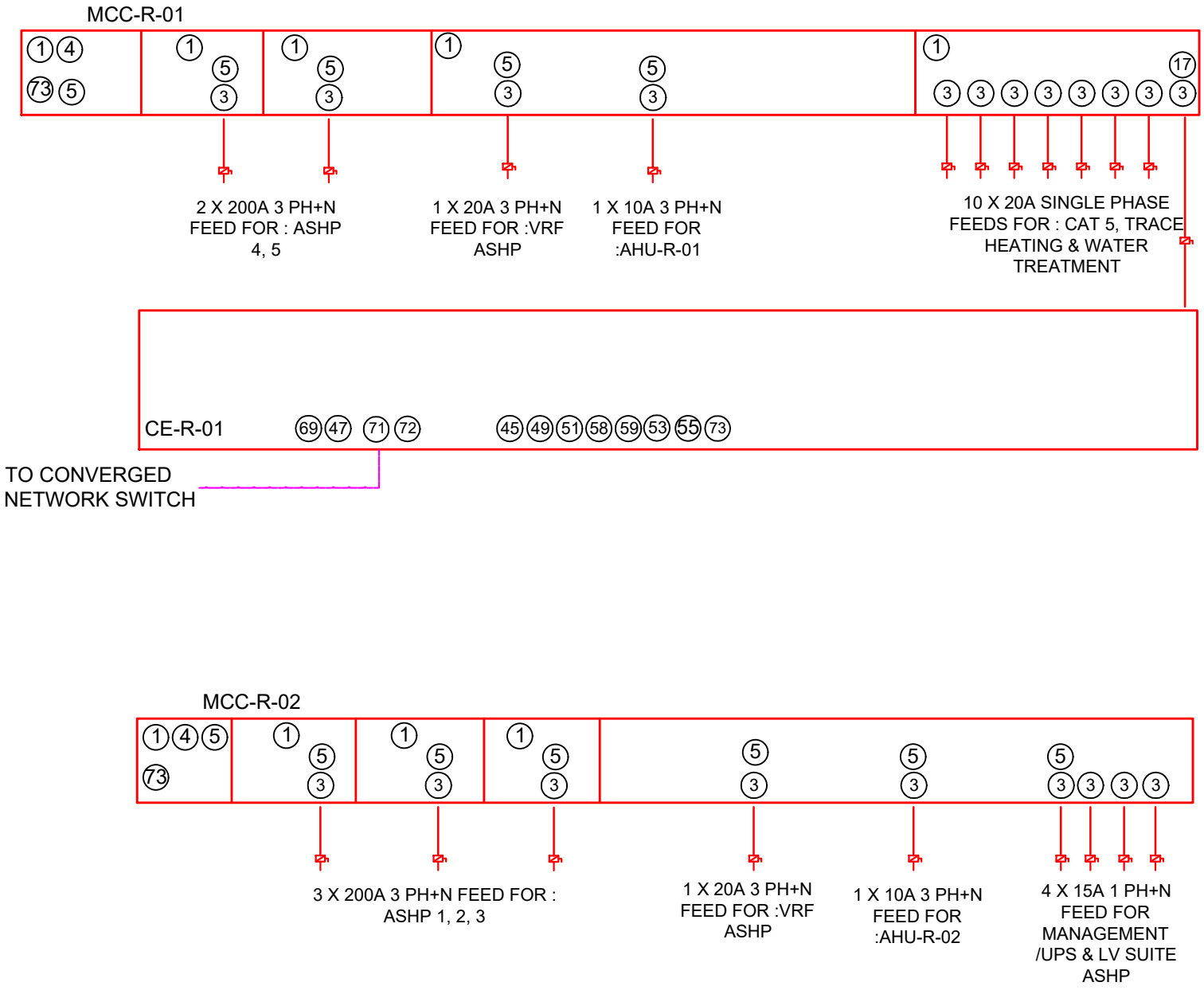
Title: AUTOMATIC CONTROLS
CONTROL PANEL 3

Client

Drawing Status

Designed by: Alan Jones
Designed by:
Project no.
Drawn by: Alan Jones
Date: 10-10-2021
Scales @ A3
Work to figured dimensions only
Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 0120
Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

CONTROL PANEL 4

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

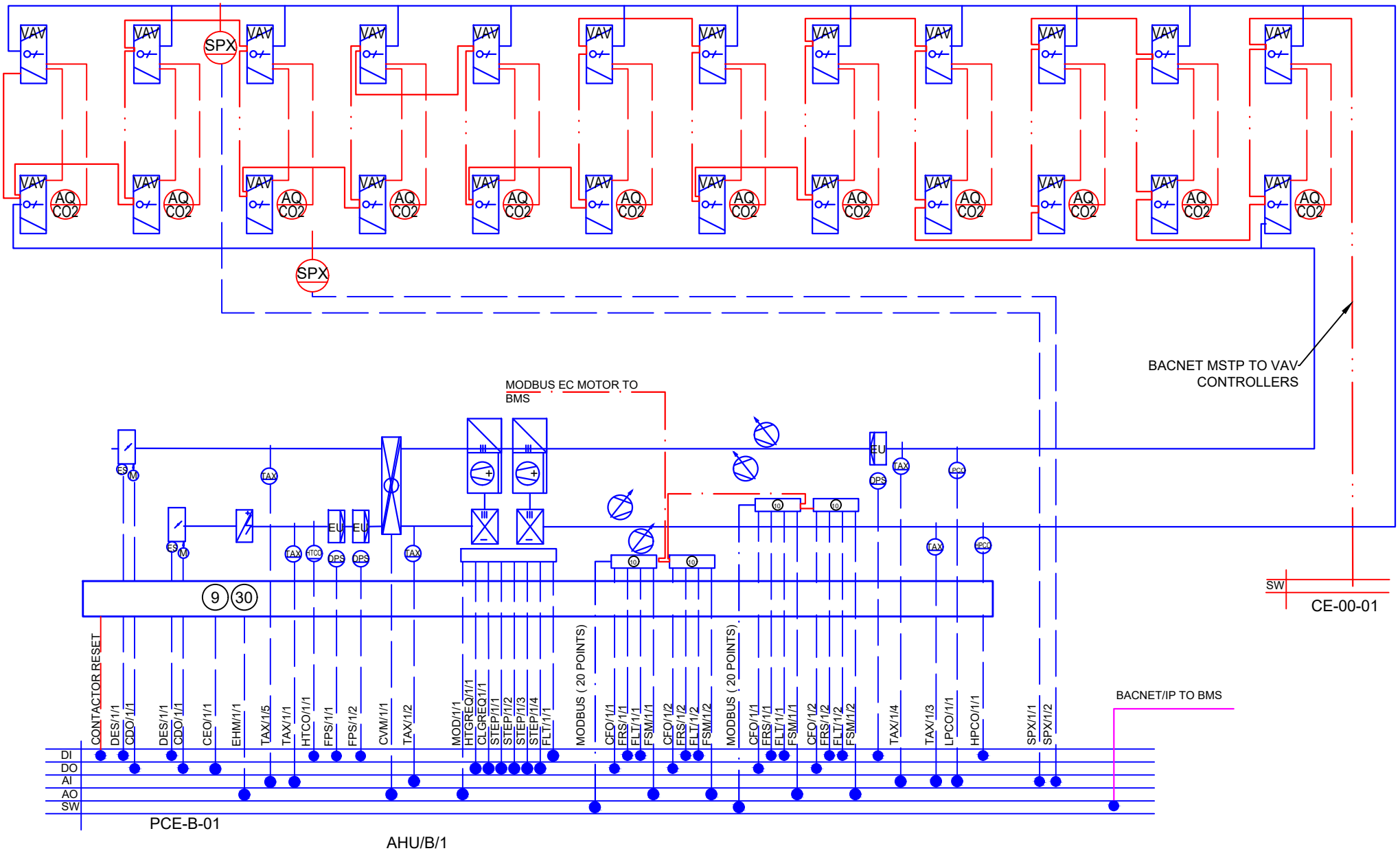
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 0130

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

VENT -1

Client

Drawing Status

Designed by: Alan Jones

Drawn by: Alan Jones

Date: 10-10-2021

Scales @ A3

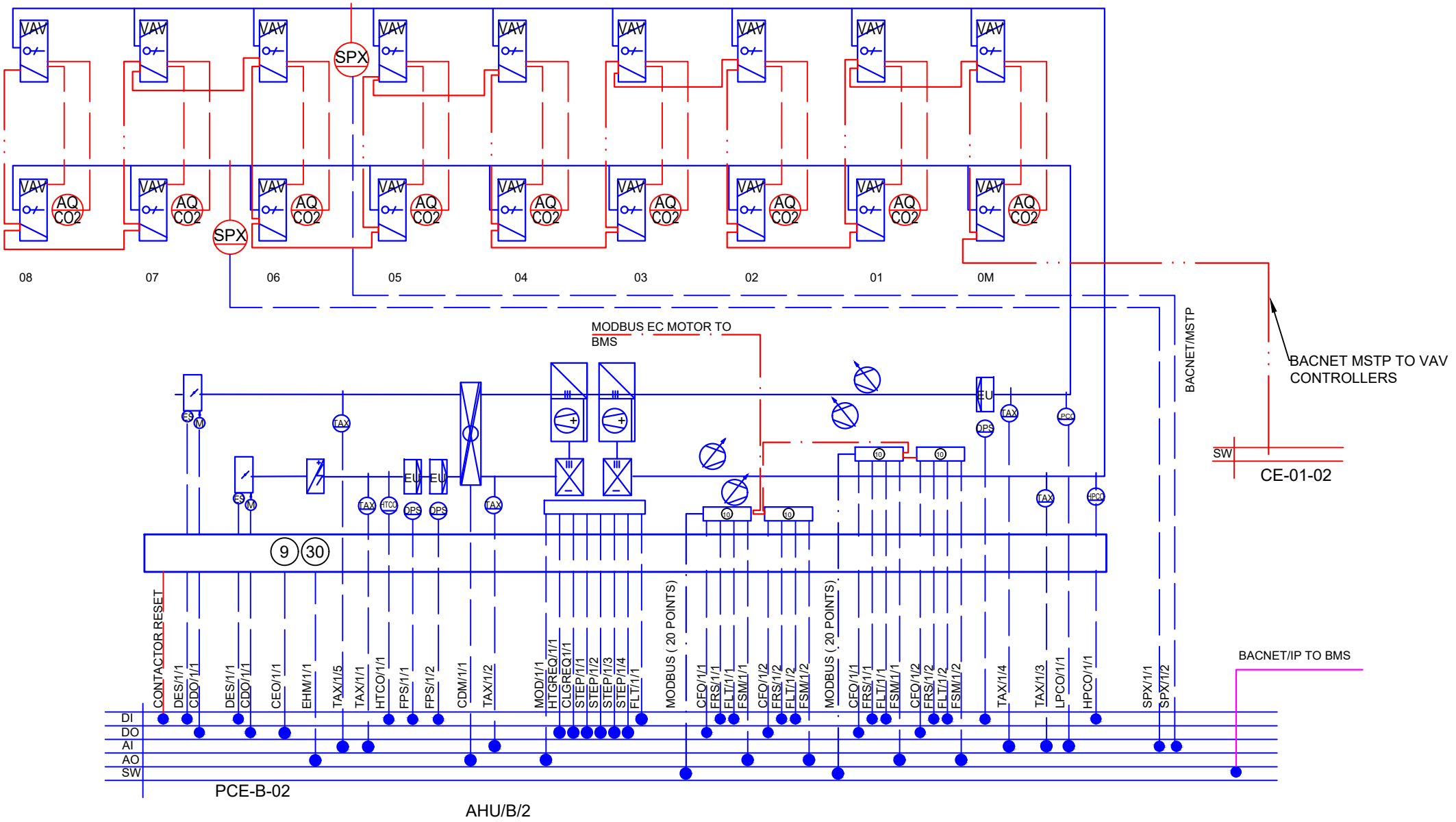
Work to figured dimensions only

Project no.

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 1010

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

VENTILATION 2

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

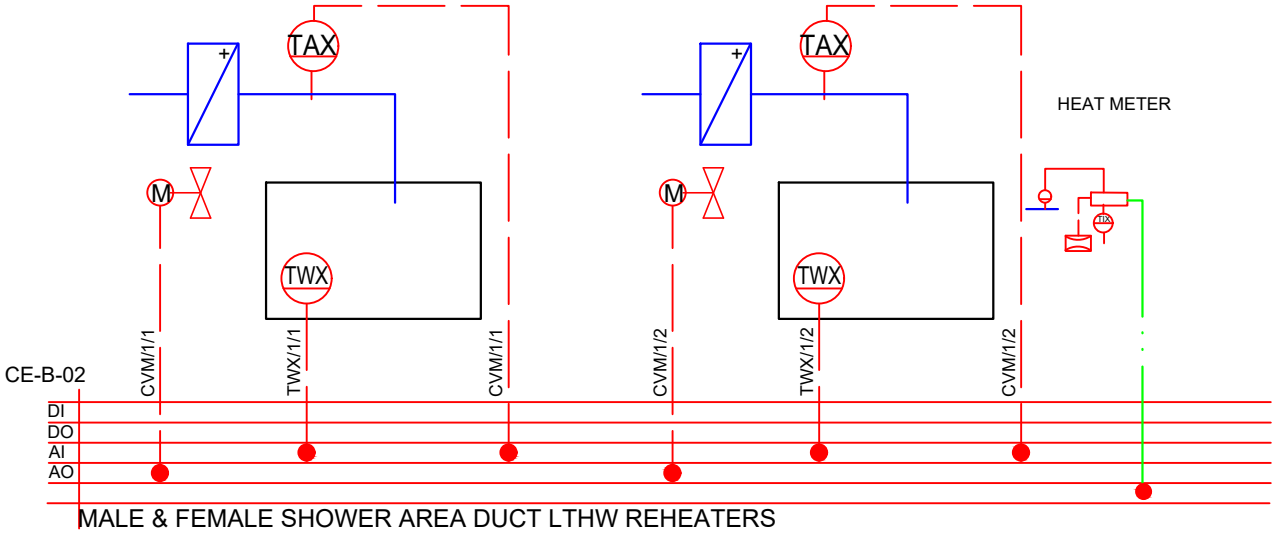
Scales @ A3

Work to figured dimensions only

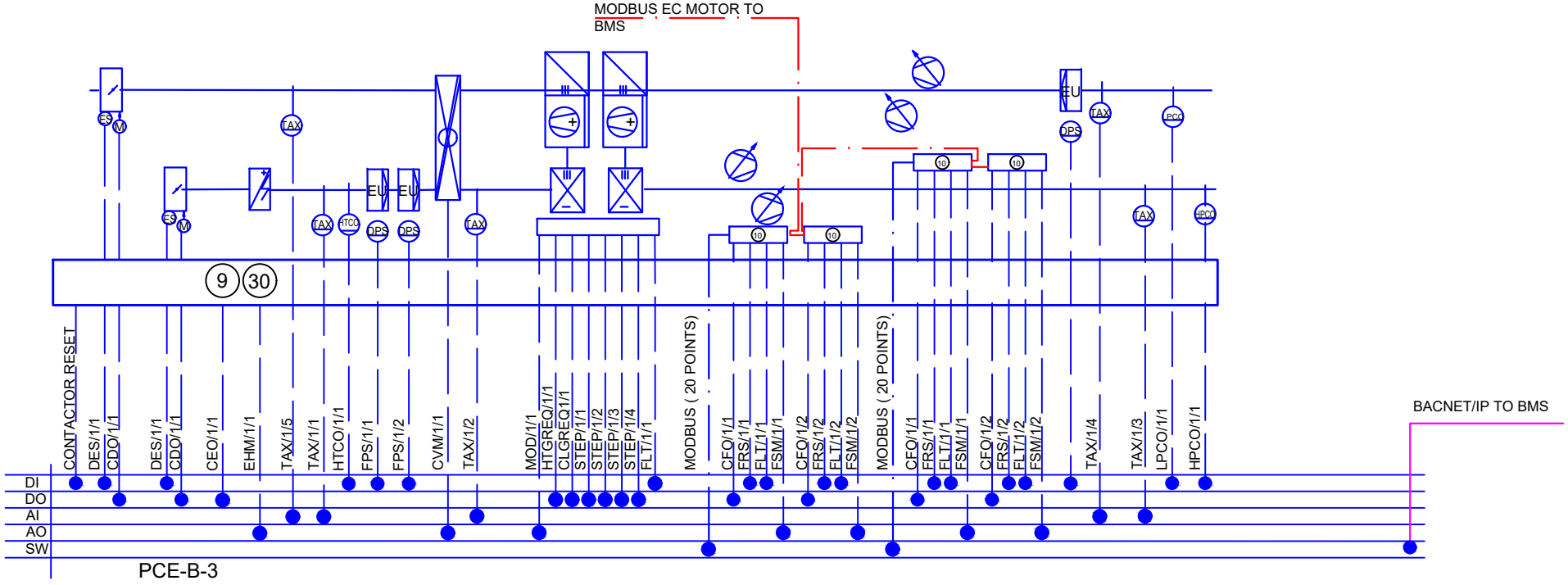
Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 1020

Revision: C-01



MALE & FEMALE SHOWER AREA DUCT LTHW REHEATERS



PCE-B-3

BASEMENT VENTILATION AHU/B/3

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

VENTILATION 3

Client

Drawing Status

Designed by: Alan Jones

Drawn by: Alan Jones

Date: 10-10-2021

Scales @ A3

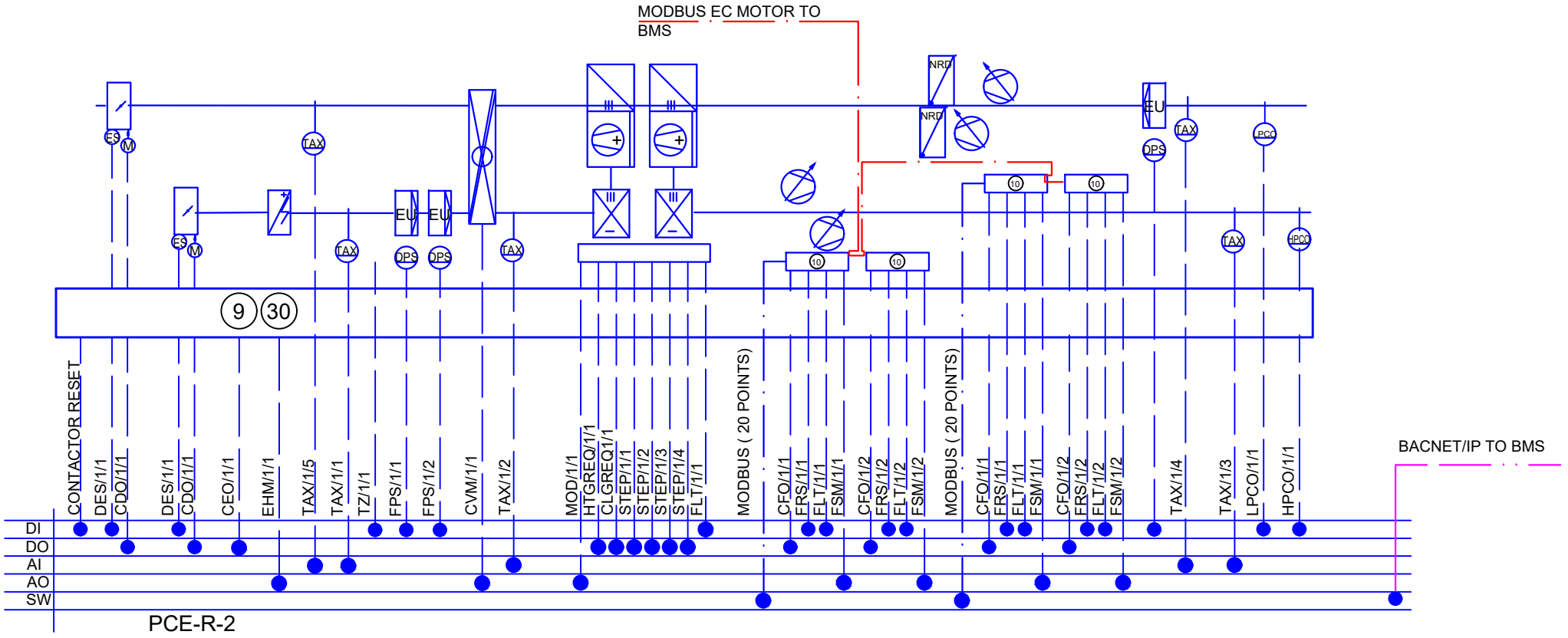
Work to figured dimensions only

Project no.

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 1030

Revision: C-01



TOILET VENTILATION AHU/R/2

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

VENTILATION 4

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

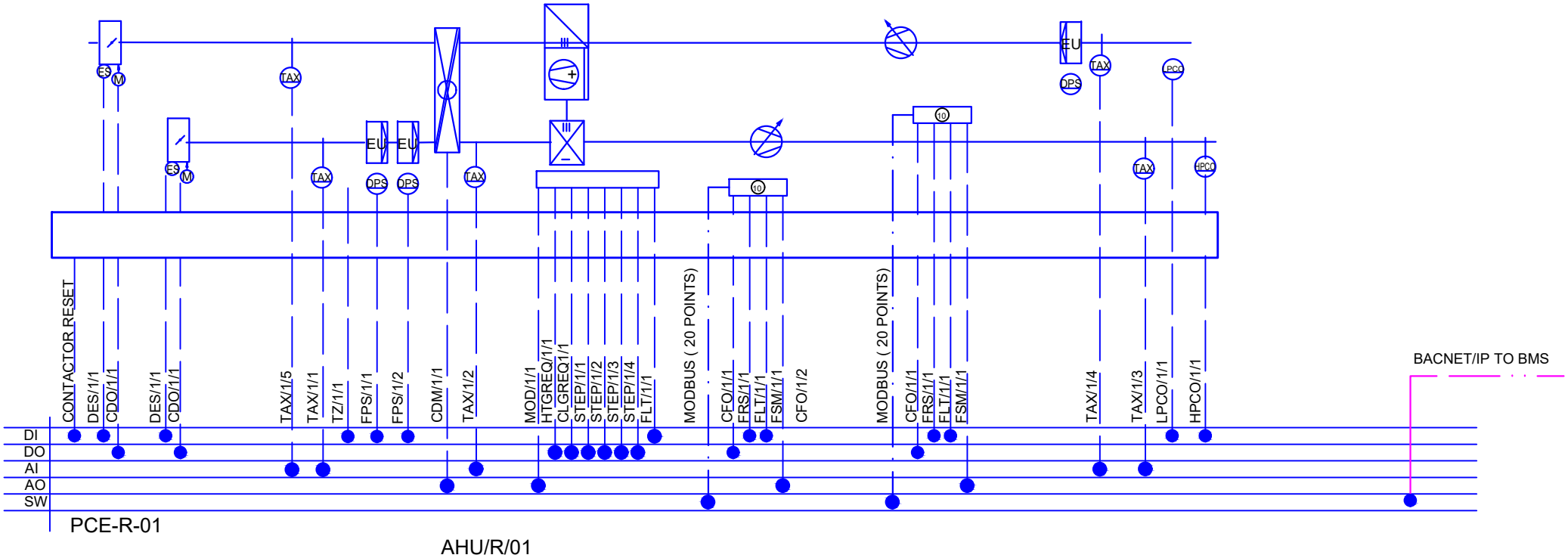
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 1040

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

VENTILATION 5

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

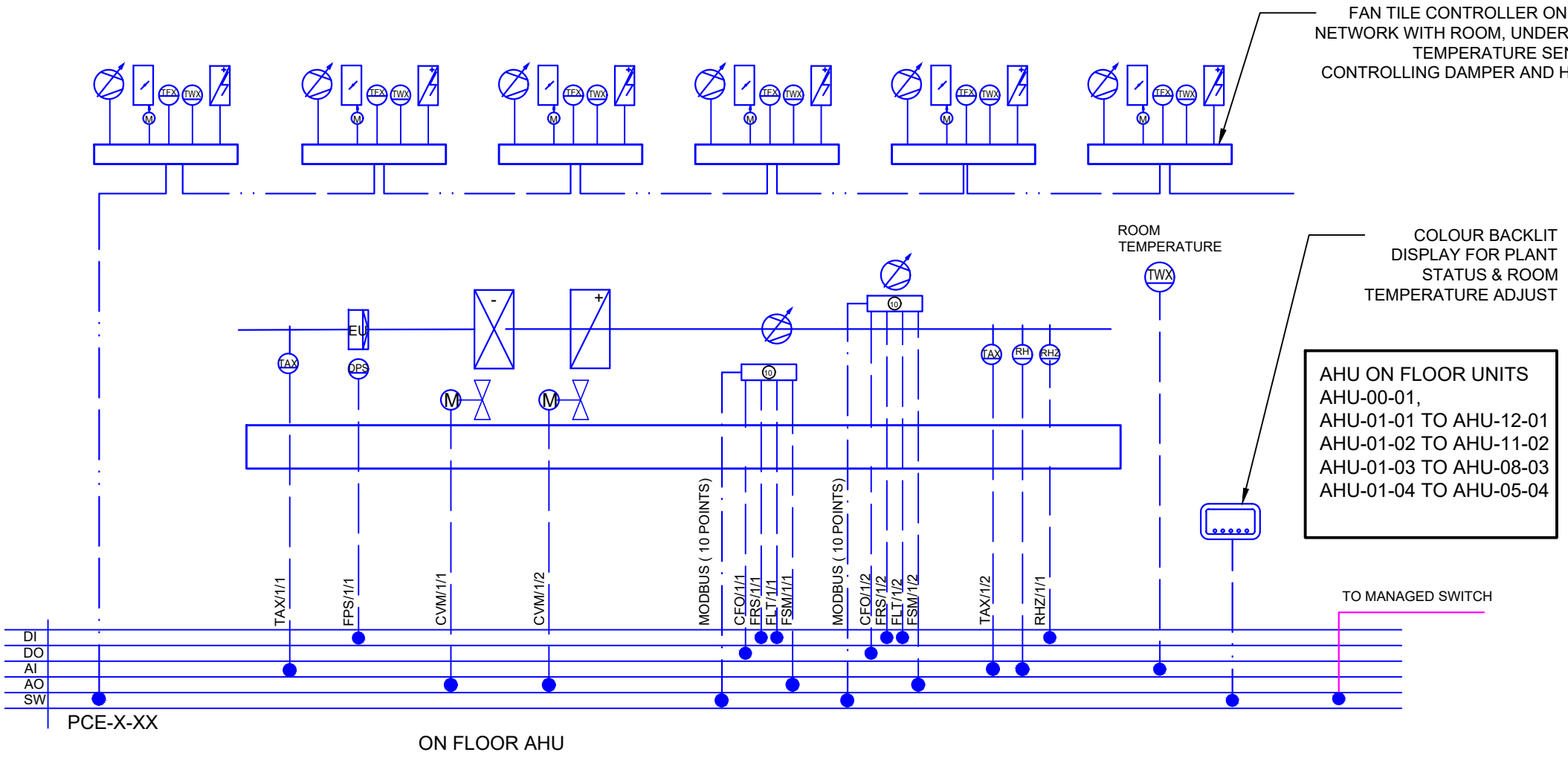
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 1050

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

VENTILATION 6
ON FLOOR AHU

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

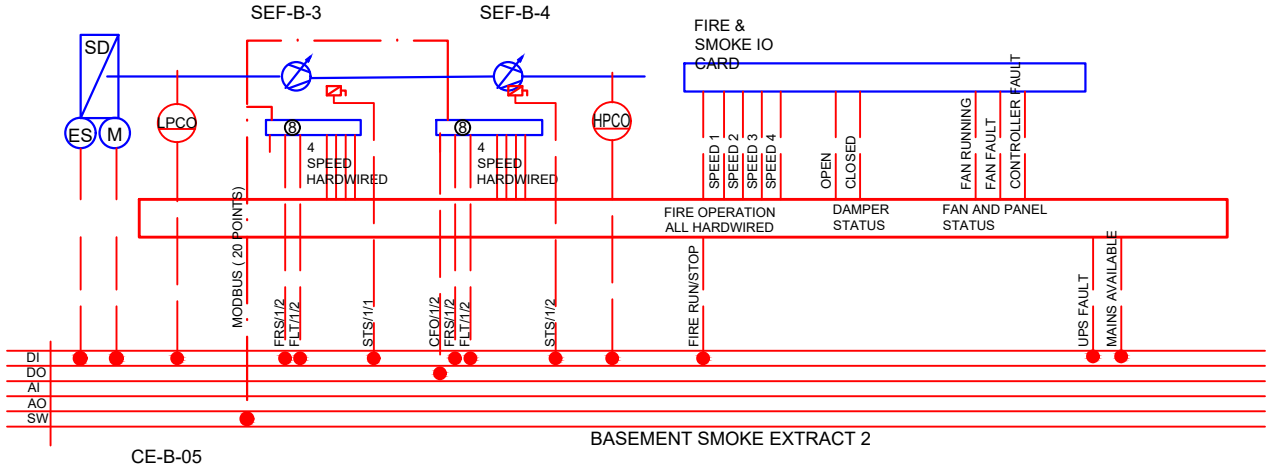
Scales @ A3

Work to figured dimensions only

Computer file No.

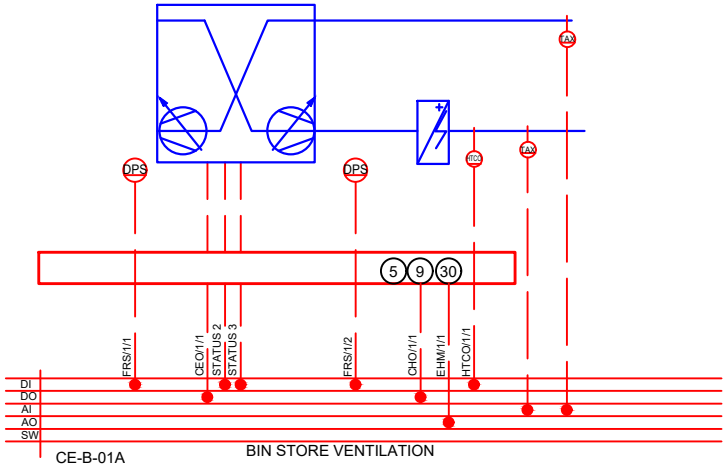
Project - Originator - Volume- level - Type - Role - Number: 1060

Revision: C-01



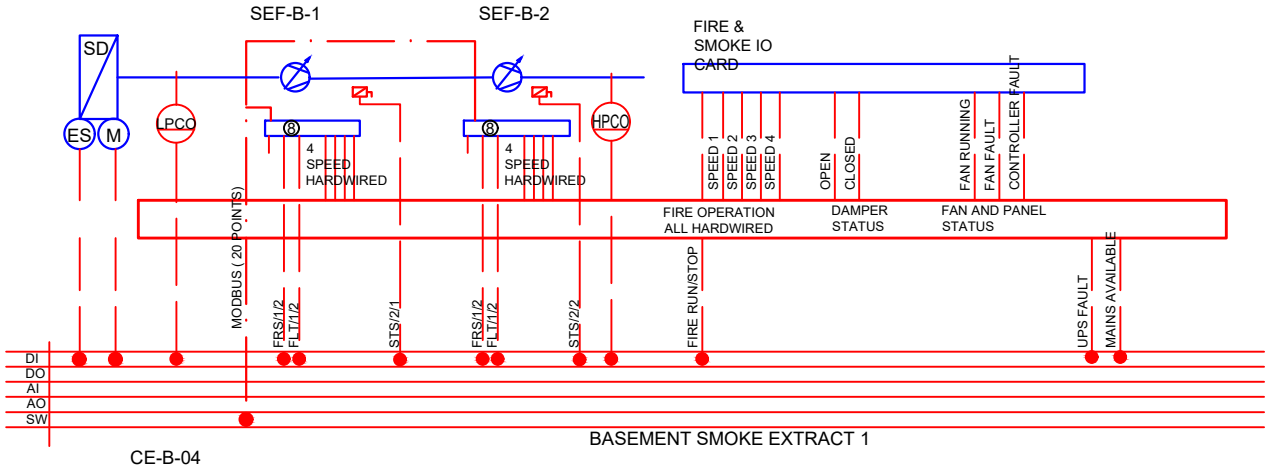
CE-B-05

BASEMENT SMOKE EXTRACT 2



CE-B-01A

BIN STORE VENTILATION



CE-B-04

BASEMENT SMOKE EXTRACT 1

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

VENTILATION 07

Client

Drawing Status

Designed by: Alan Jones

Drawn by: Alan Jones

Date: 10-10-2021

Scales @ A3

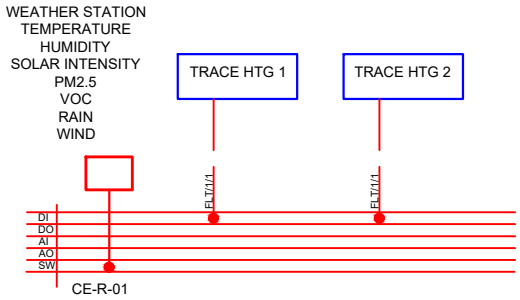
Work to figured dimensions only

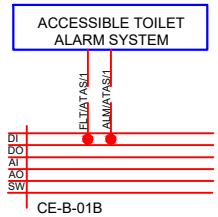
Project no.

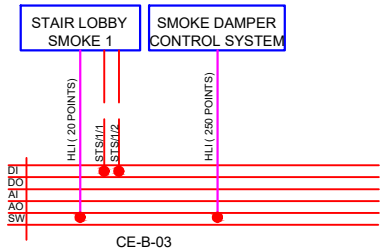
Computer file No.

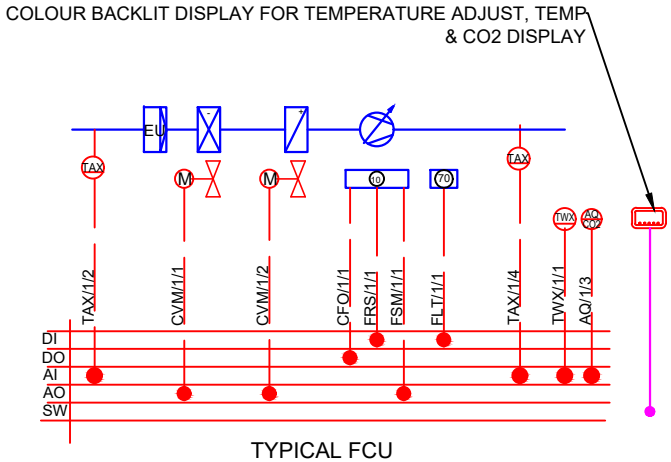
Project - Originator - Volume- level - Type - Role - Number: 2010

Revision: C-01

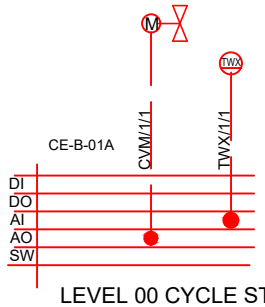




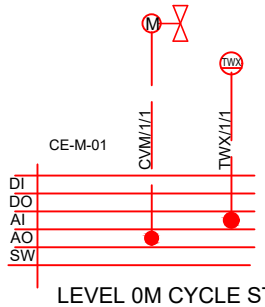




TYPICAL FCU



LEVEL 00 CYCLE STORE
RADIATORS



LEVEL 0M CYCLE STORE
RADIATORS

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

GENERAL CONTROL &
MONITORING 1

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

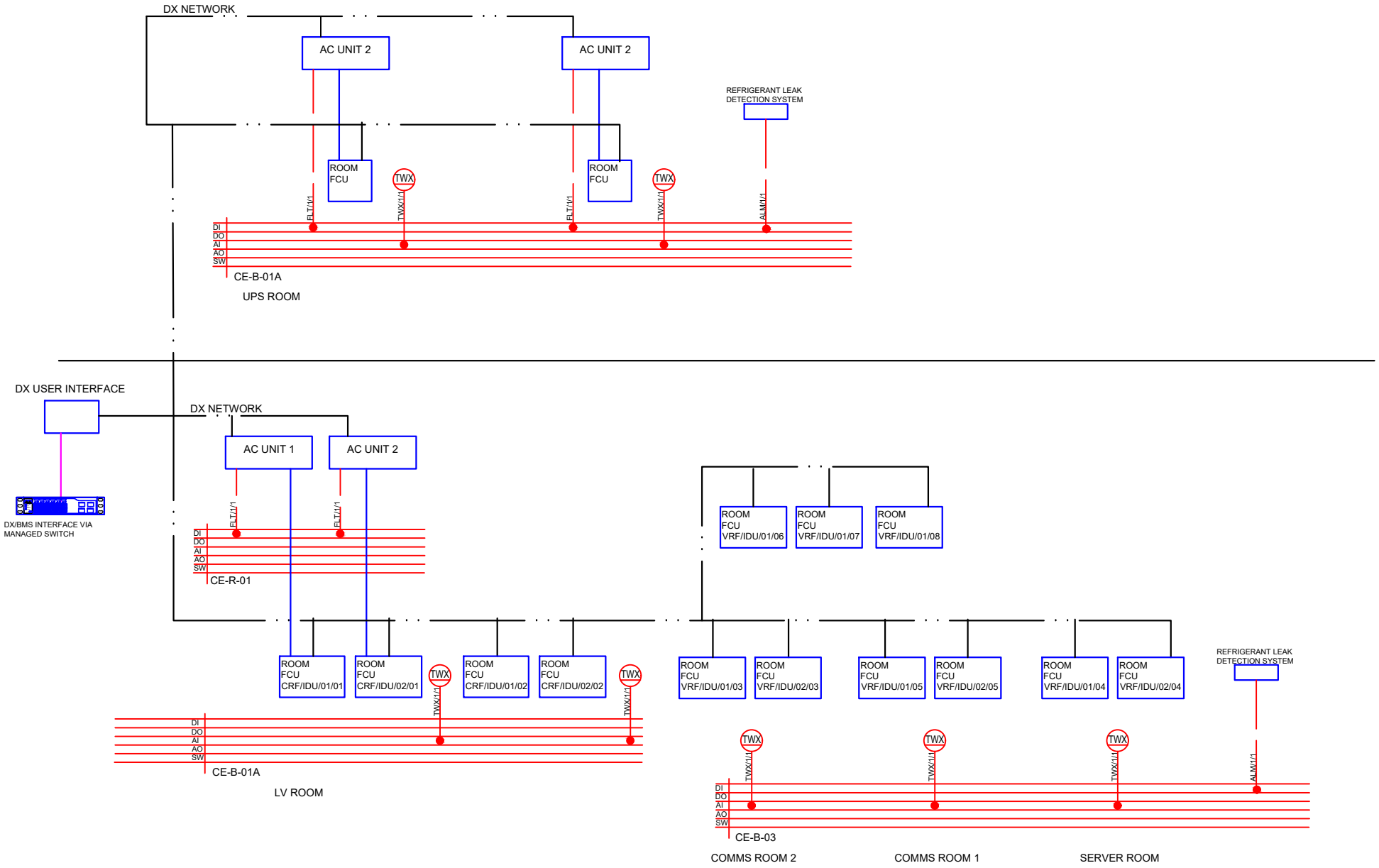
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 3010

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

GENERAL CONTROL & MONITORING 2

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

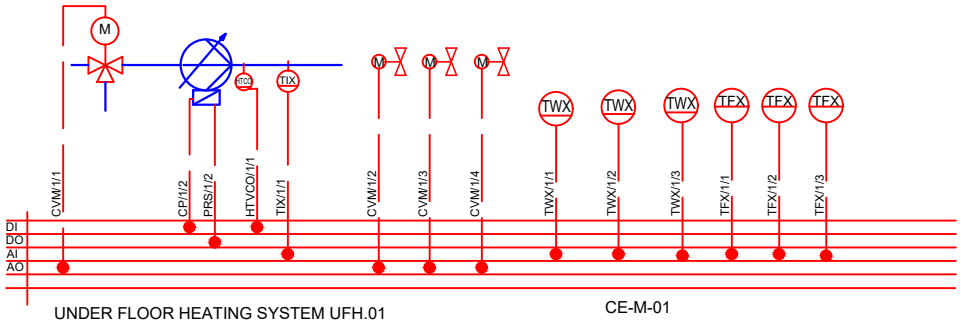
Scales @ A3

Work to figured dimensions only

Computer file No.

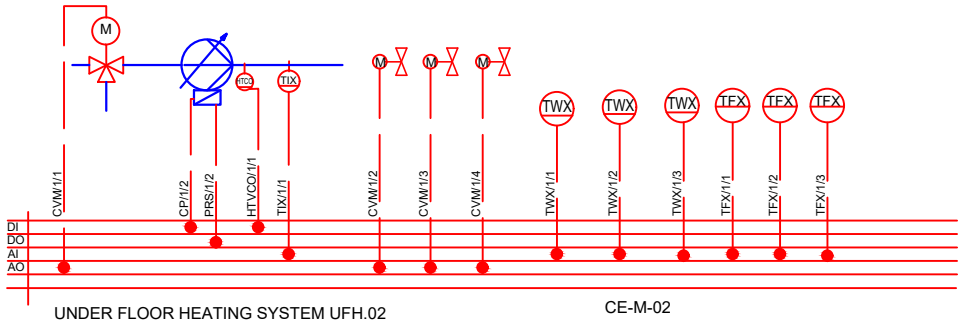
Project - Originator - Volume- level - Type - Role - Number: 3015

Revision: C-01



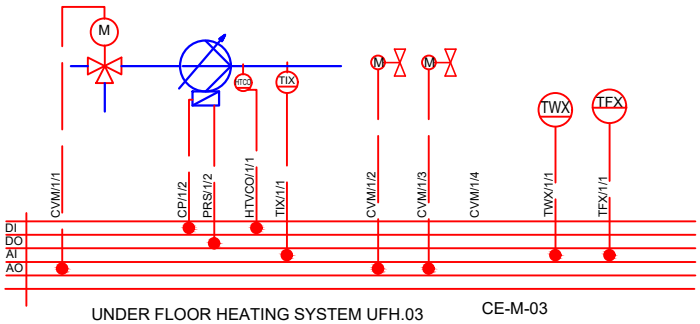
UNDER FLOOR HEATING SYSTEM UFH.01

CE-M-01



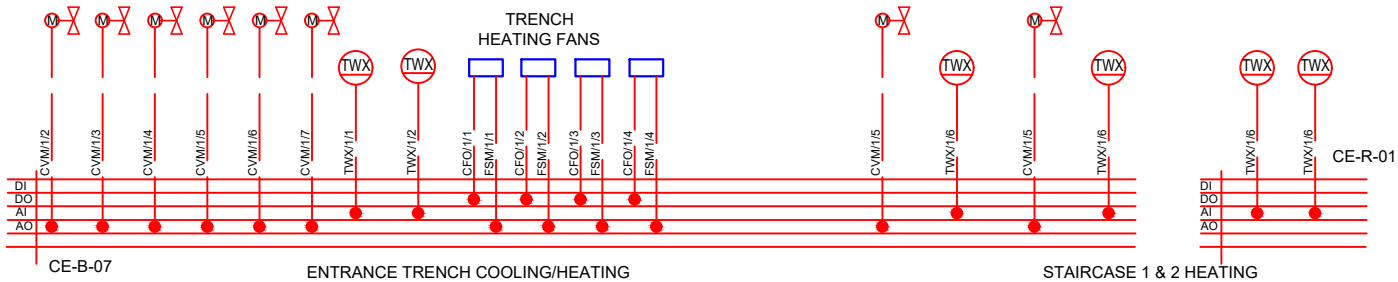
UNDER FLOOR HEATING SYSTEM UFH.02

CE-M-02



UNDER FLOOR HEATING SYSTEM UFH.03

CE-M-03



CE-B-07

ENTRANCE TRENCH COOLING/HEATING

STAIRCASE 1 & 2 HEATING

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By

Amendments

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

GENERAL CONTROL & MONITORING 3

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

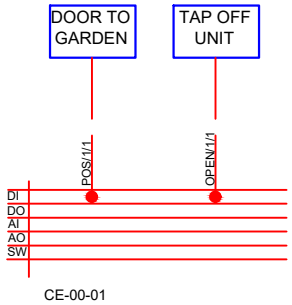
Scales @ A3

Work to figured dimensions only

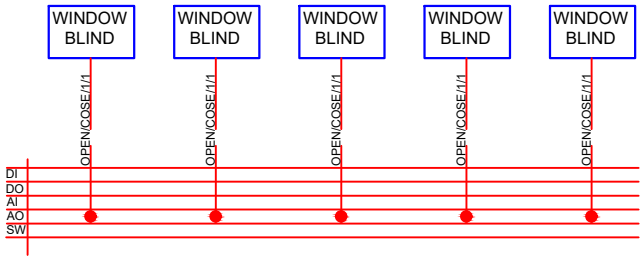
Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 3020

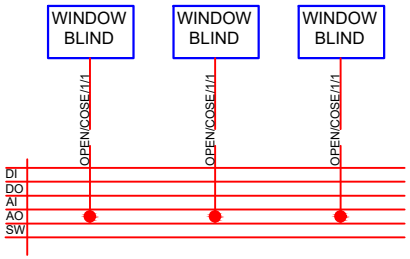
Revision: C-01



CE-00-01

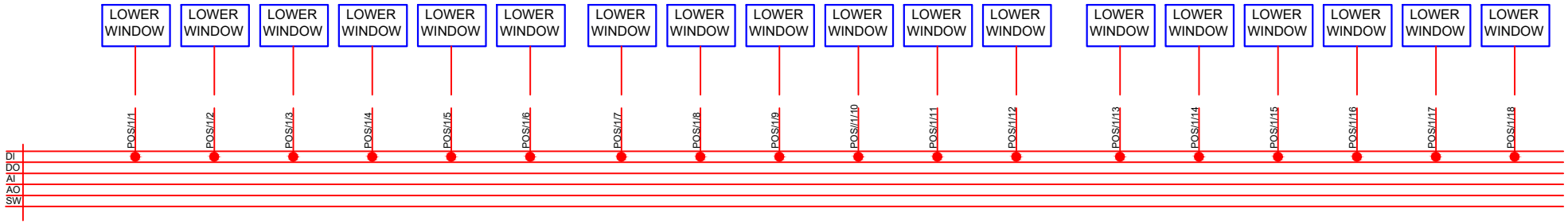


CE-R-01



CE-09-01 CE-08-01 CE-06-02 CE-05-01

WINDOW AND AWNING CONTROL AND MONITORING



WINDOW AND AWNING CONTROL AND MONITORING

TYPICAL POINTS FOR
EACH OUTSTATION - 2
PER FLOOR

CE-01-01	CE-01-02
CE-02-01	CE-02-02
CE-03-01	CE-03-02
CE-04-01	CE-04-02
CE-05-01	CE-05-02
CE-06-01	CE-06-02
CE-07-01	CE-07-02
CE-08-01	CE-08-02
CE-09-01	CE-09-02
CE-10-01	CE-10-02
CE-11-01	CE-11-02
CE-R-01	

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

GENERAL CONTROL & MONITORING 4

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

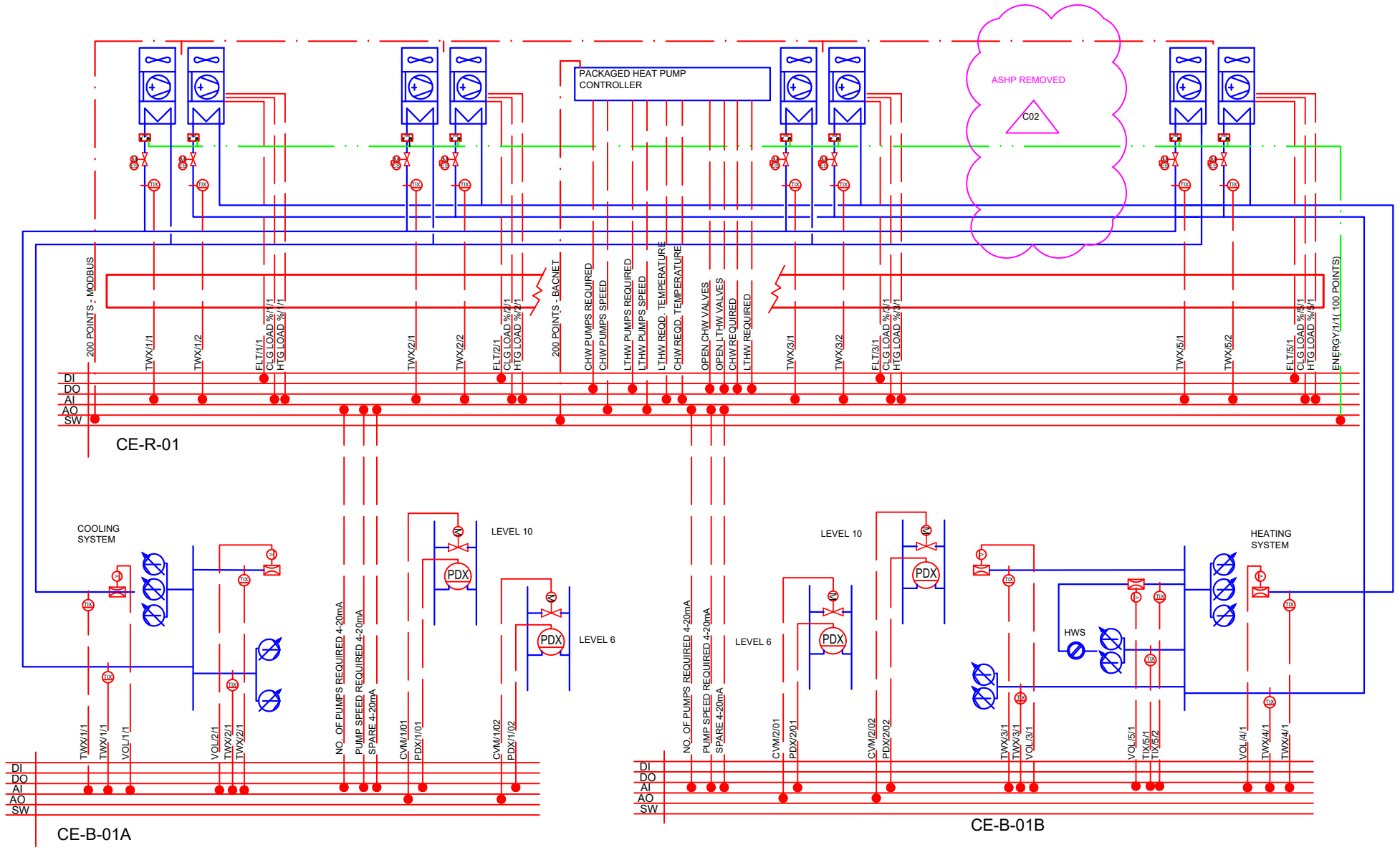
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 3030

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
CO2	oct/22	Heat pumps now 4 was 5	

Amendments

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

HEAT PUMPS

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

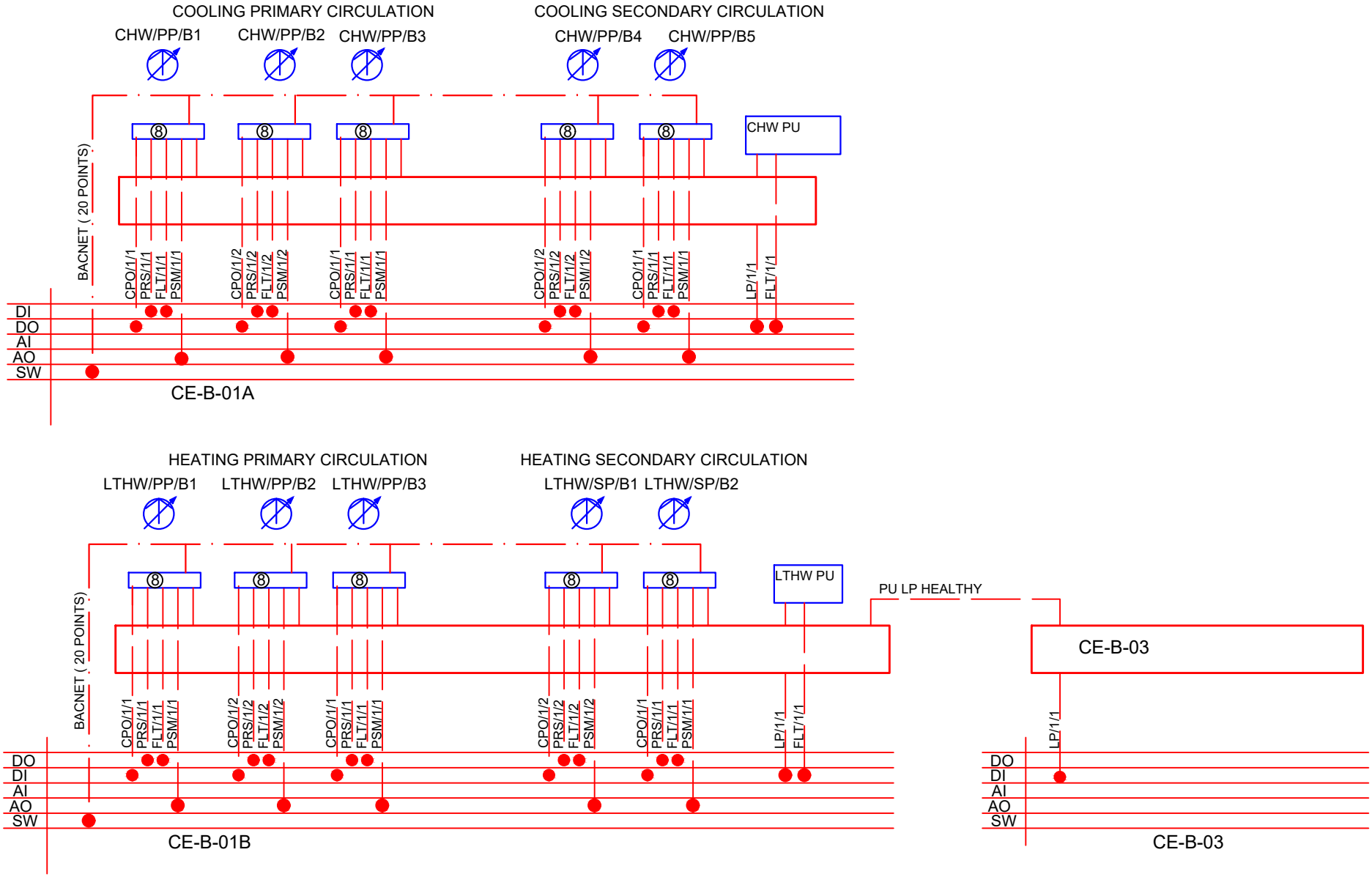
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 5010

Revision: C-02



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS
CIRCULATION PUMPS

Client

Drawing Status

Designed by: Alan Jones

Drawn by: Alan Jones

Date: 10-10-2021

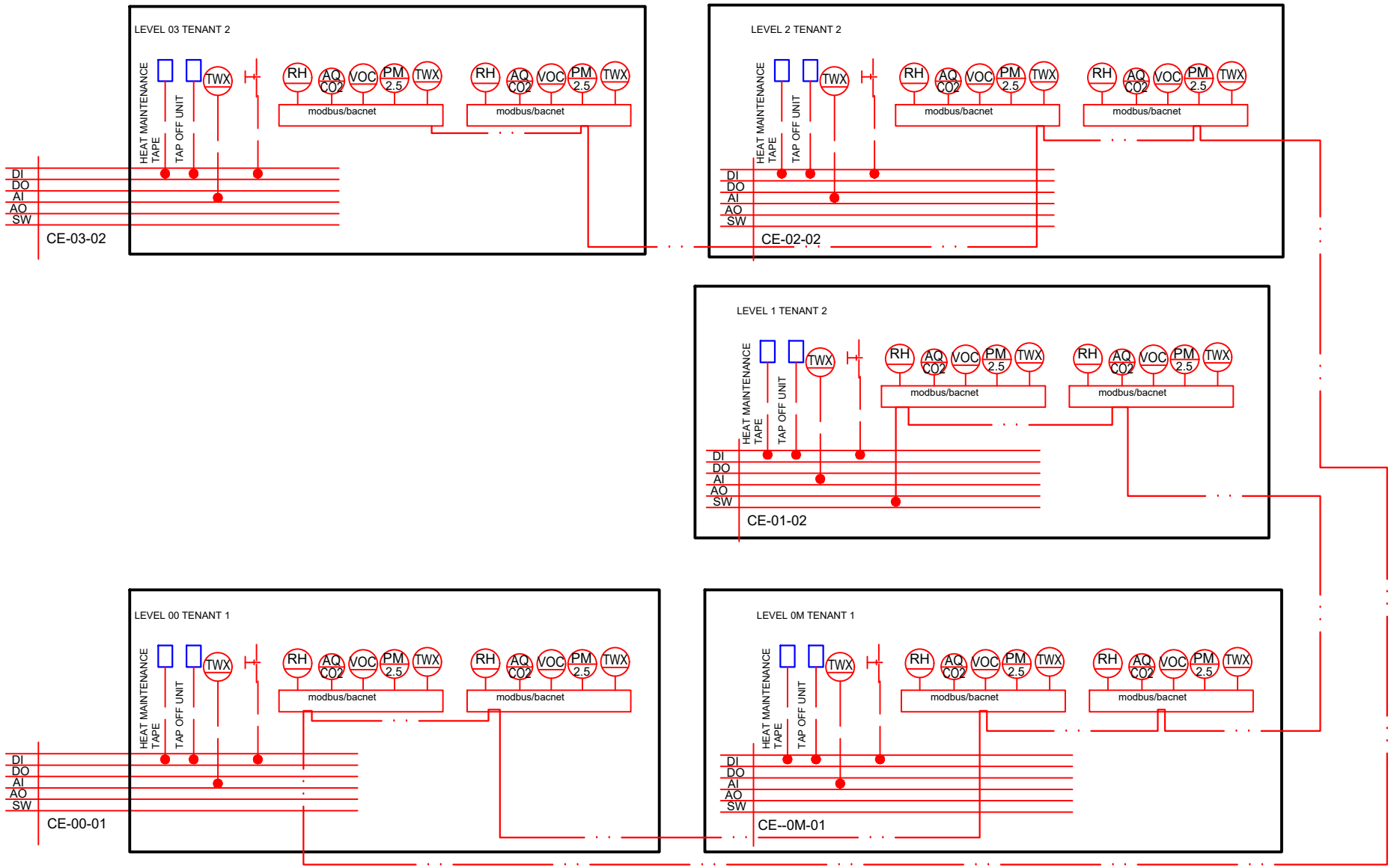
Scales @ A3
Work to figured dimensions only

Project no.

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 5020

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

TENANT FLOOR MONITORING 1

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

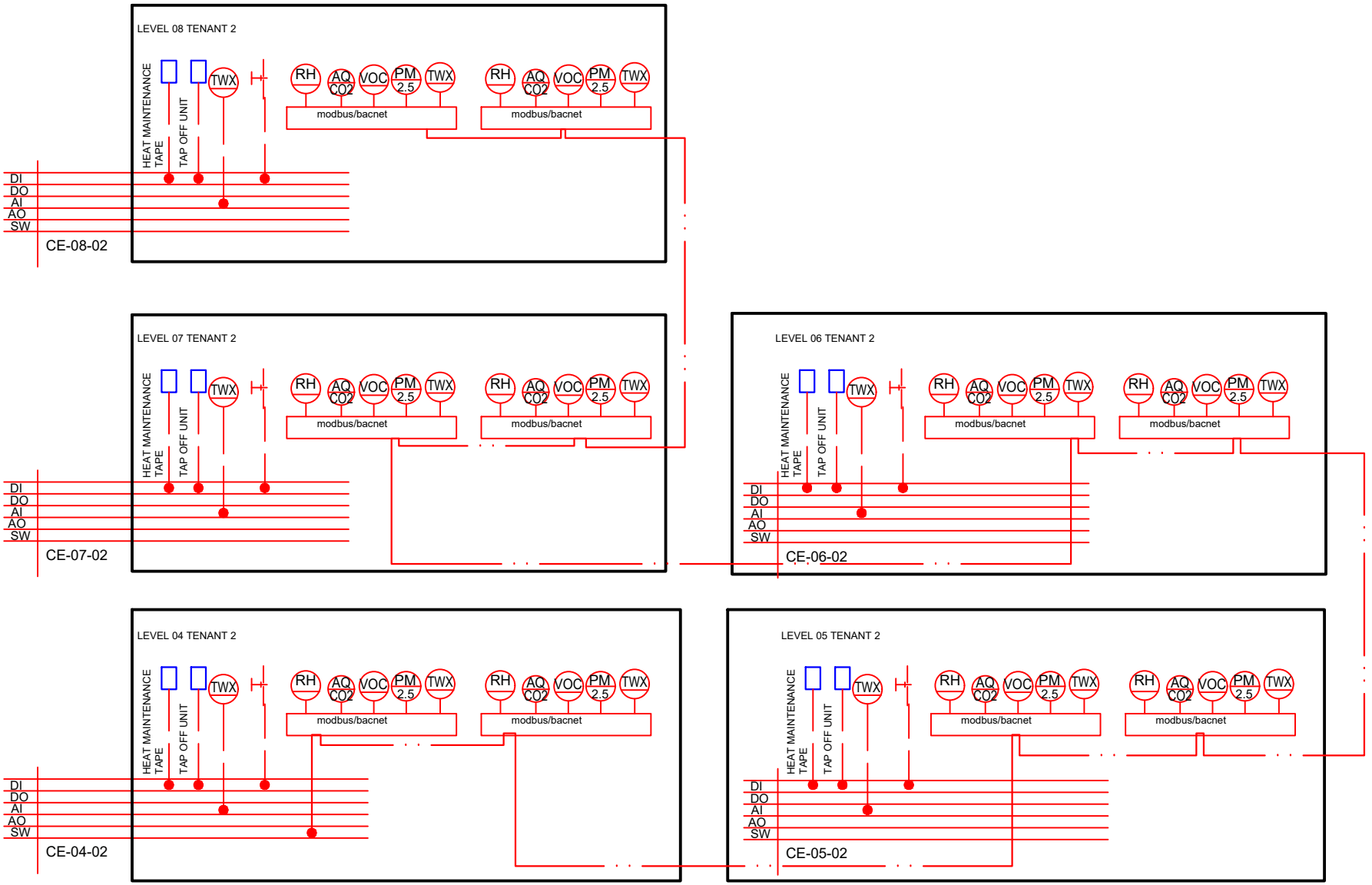
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 6010

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

TENANT FLOOR MONITORING 2

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

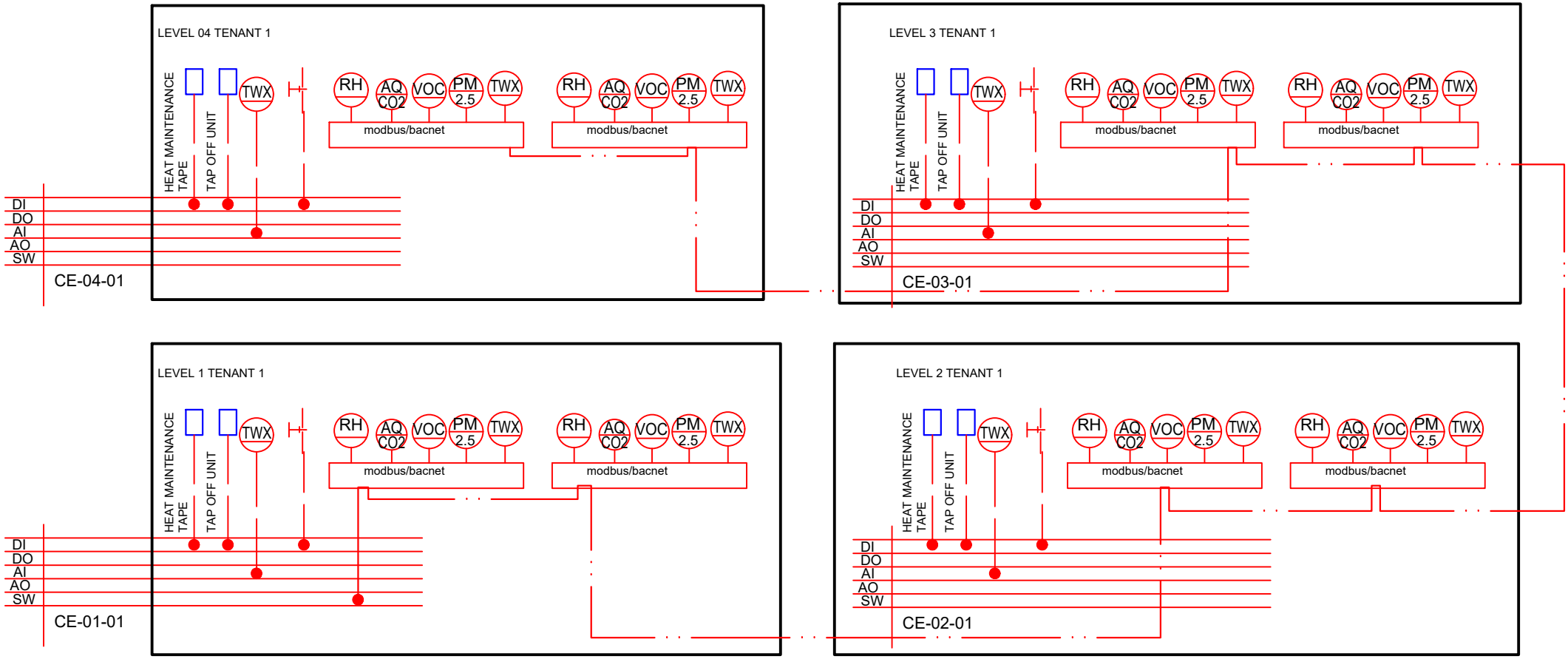
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 6020

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By

Amendments

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

TENANT FLOOR MONITORING 3

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

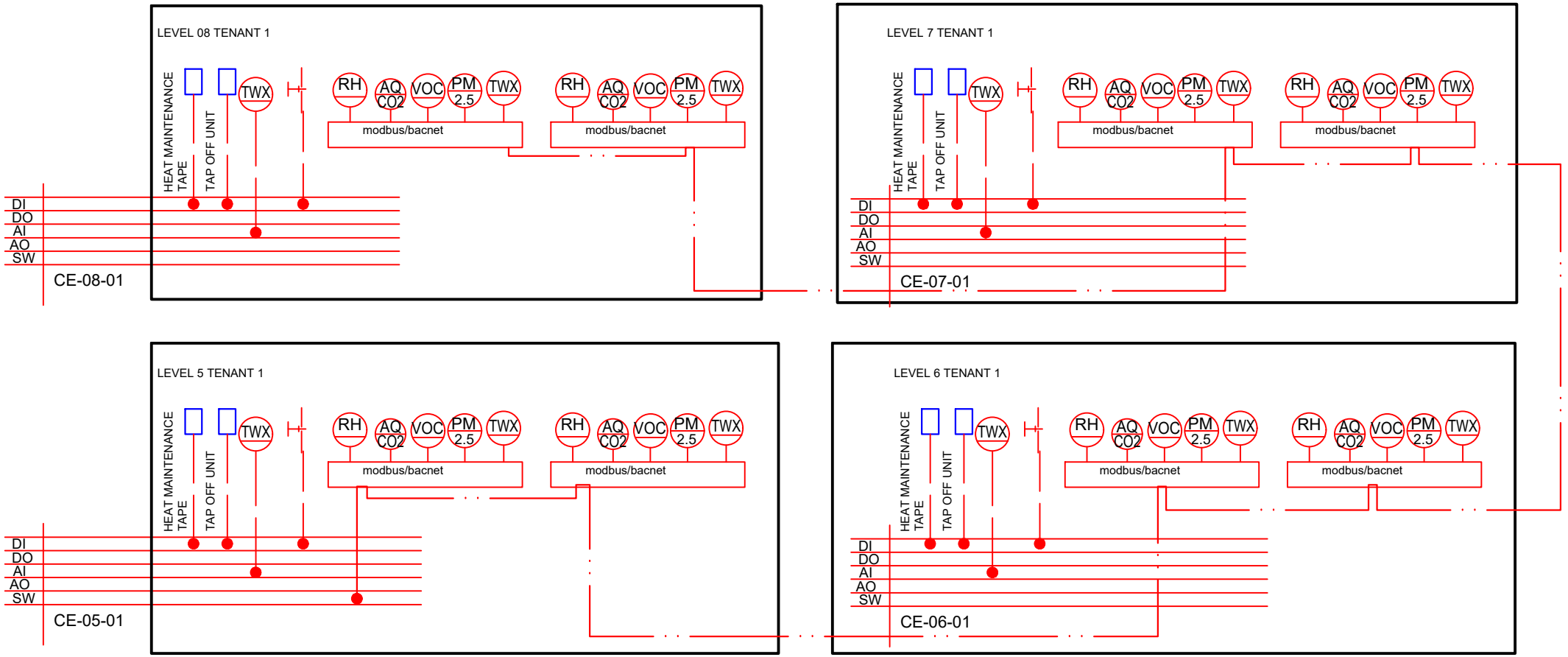
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 6030

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

TENANT FLOOR MONITORING 4

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

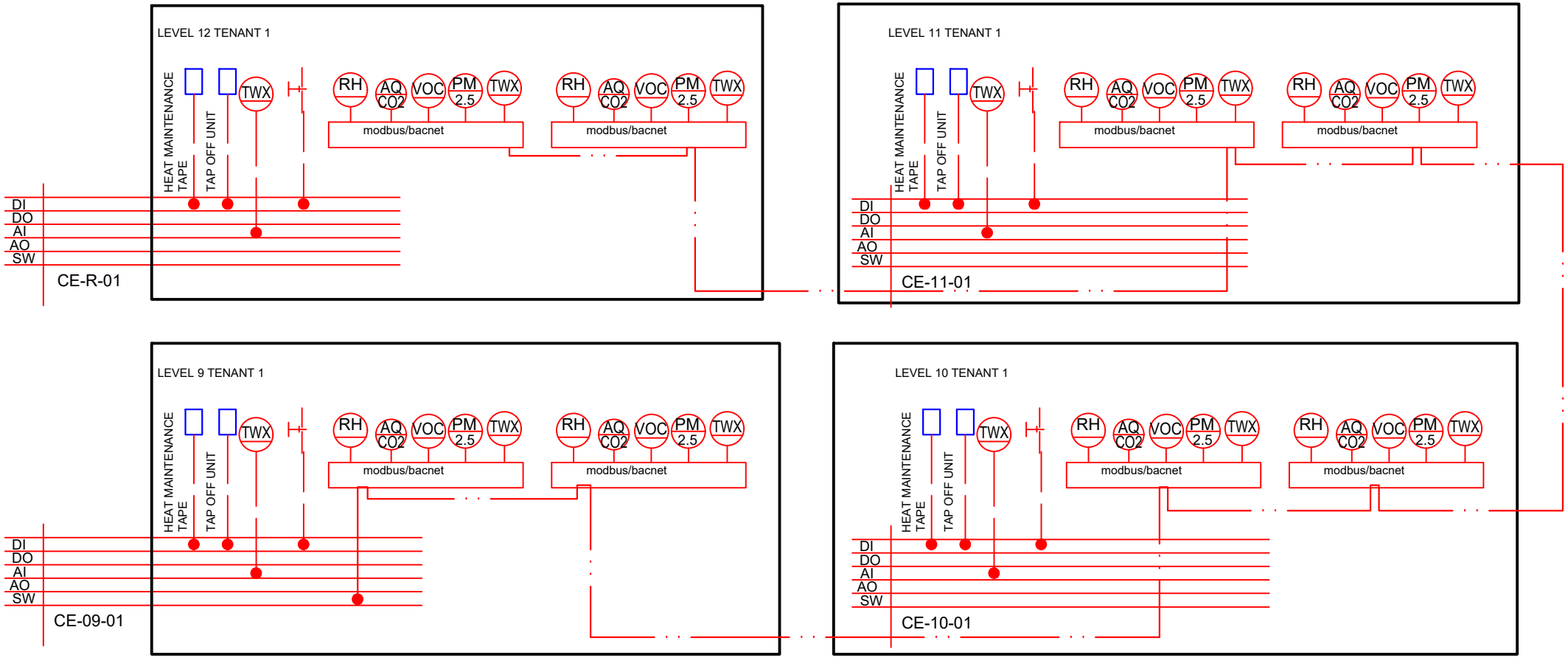
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 6040

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

TENANT FLOOR MONITORING 5

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

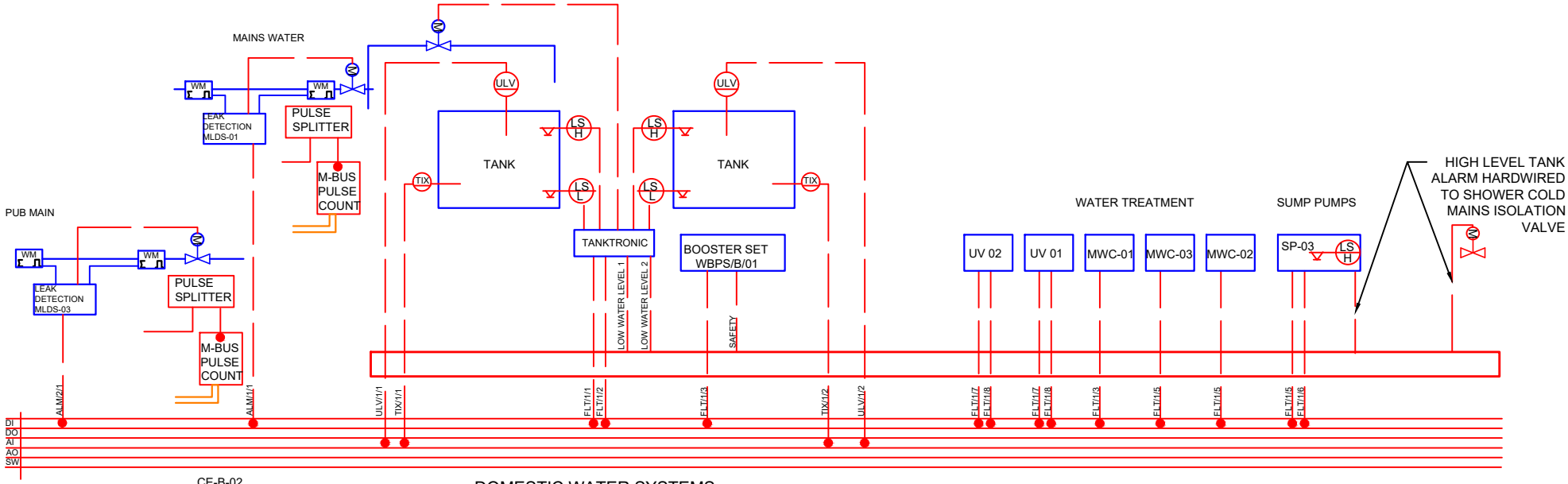
Scales @ A3

Work to figured dimensions only

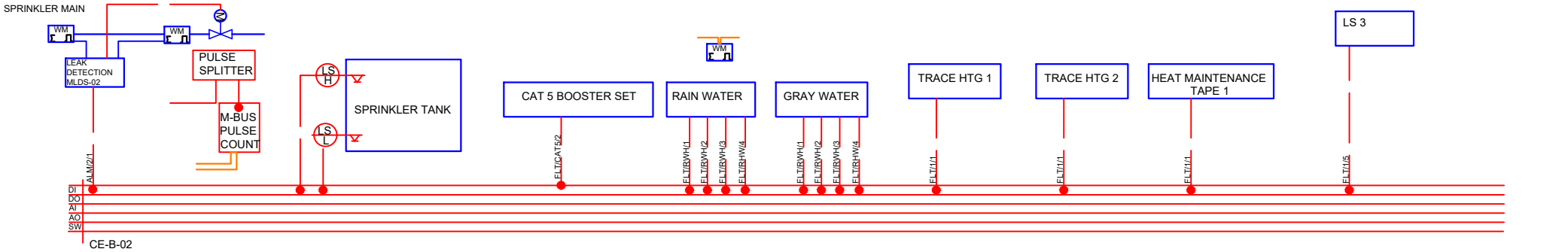
Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 6050

Revision: C-01



DOMESTIC WATER SYSTEMS



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

PUBLIC HEALTH SERVICES - 1

Client

Drawing Status

Designed by: Alan Jones

Drawn by: Alan Jones

Date: 10-10-2021

Scales @ A3

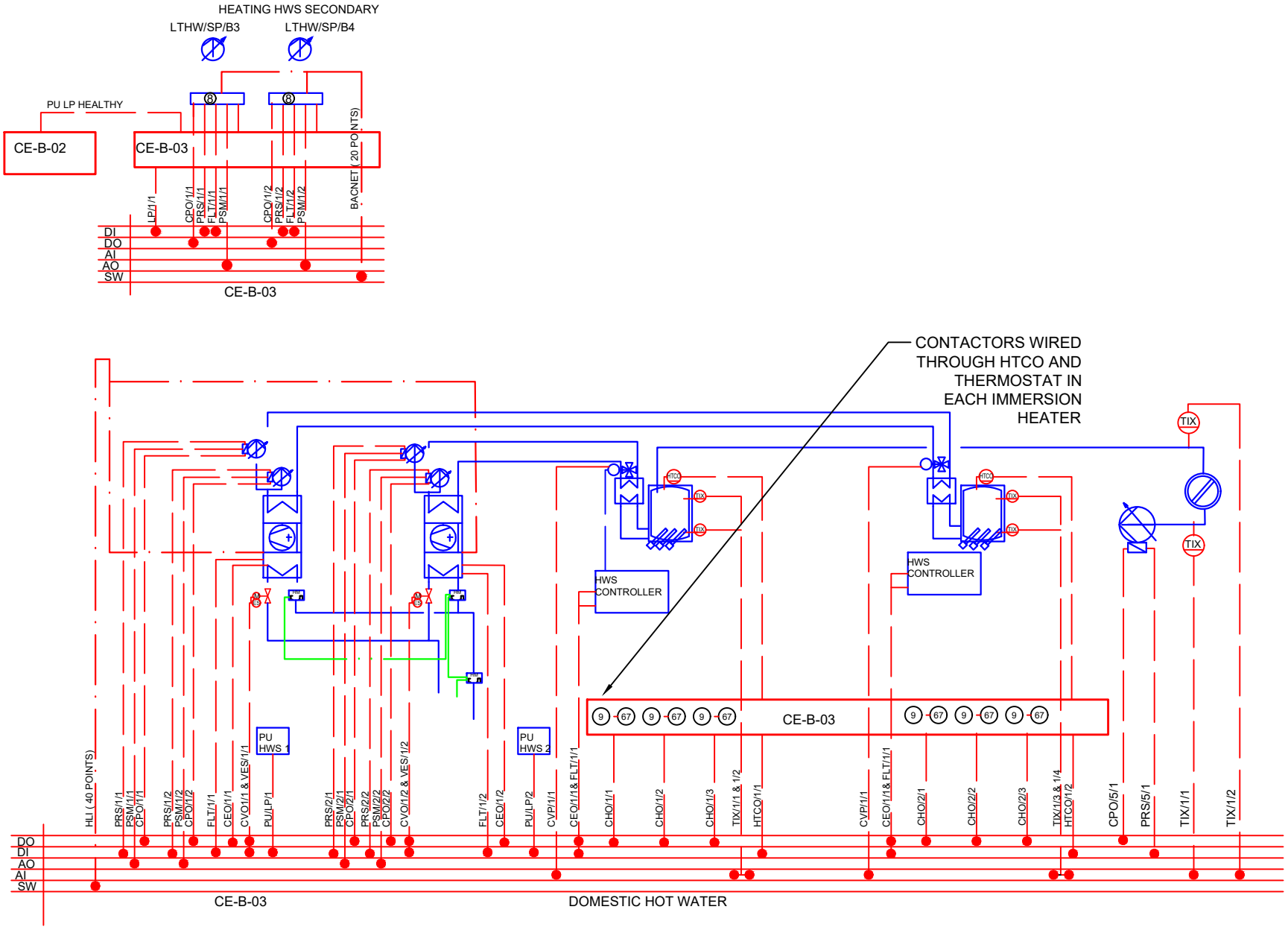
Work to figured dimensions only

Project no.

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 7010

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

PUBLIC HEALTH SERVICES - 2

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

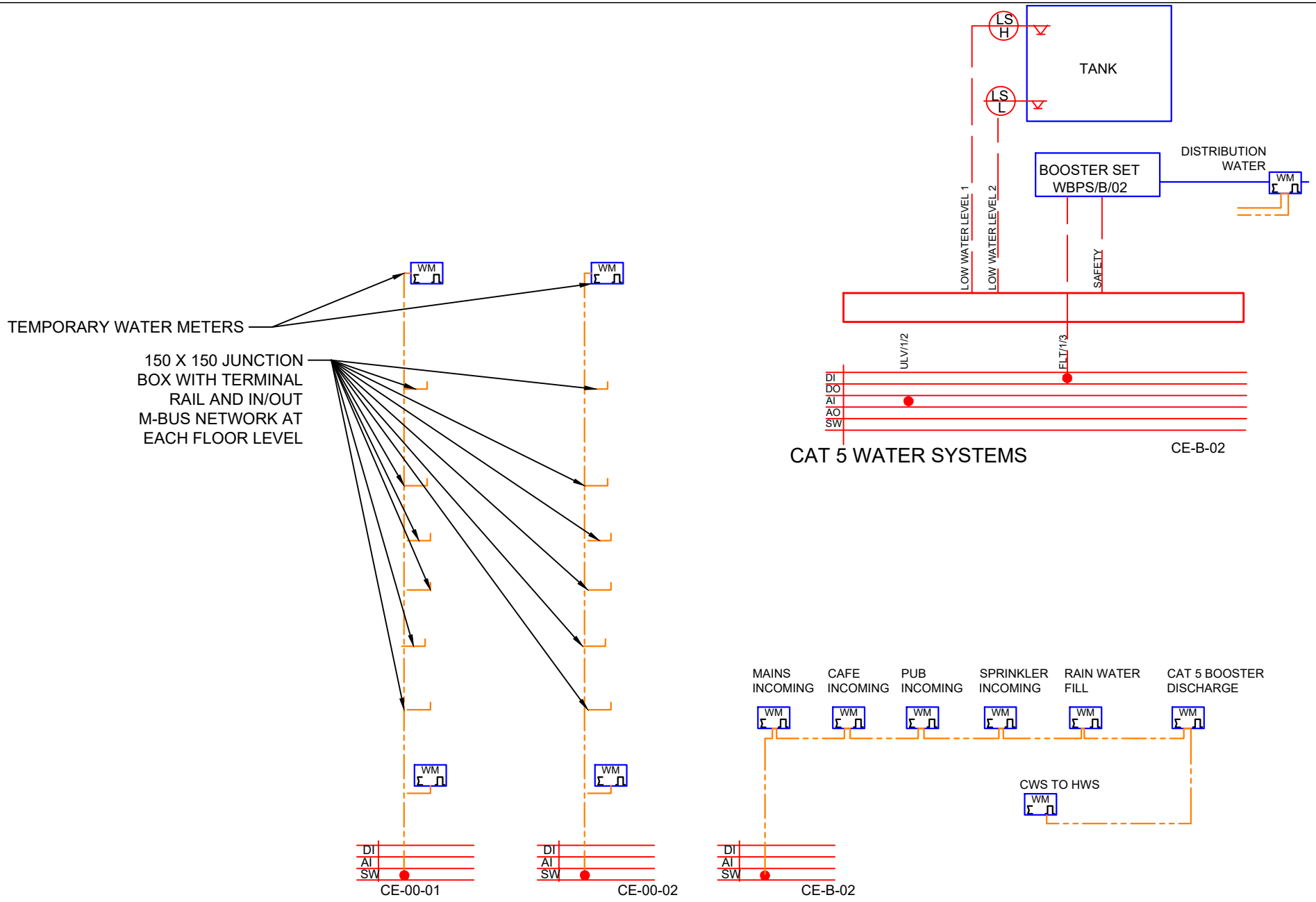
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 7020

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

PUBLIC HEALTH SERVICES - 3

Client

Drawing Status

Designed by: Alan Jones

Drawn by: Alan Jones

Date: 10-10-2021

Project no.

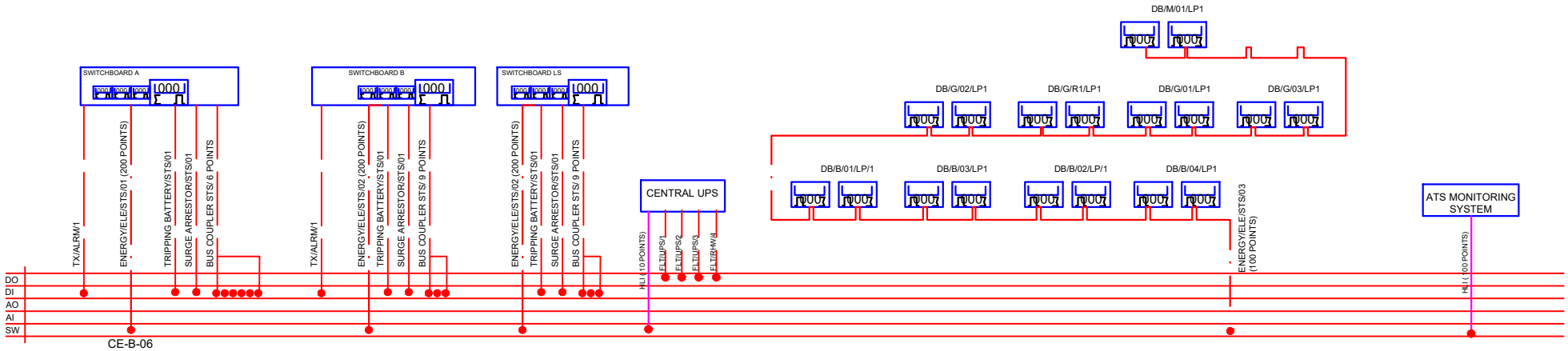
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 7040

Revision: C-01



ELECTRICAL METERING BASEMENT

SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS

ELECTRICAL MONITORING 1

Client

Drawing Status

Designed by: Alan Jones

Designed by:

Project no.

Drawn by: Alan Jones

Date: 10-10-2021

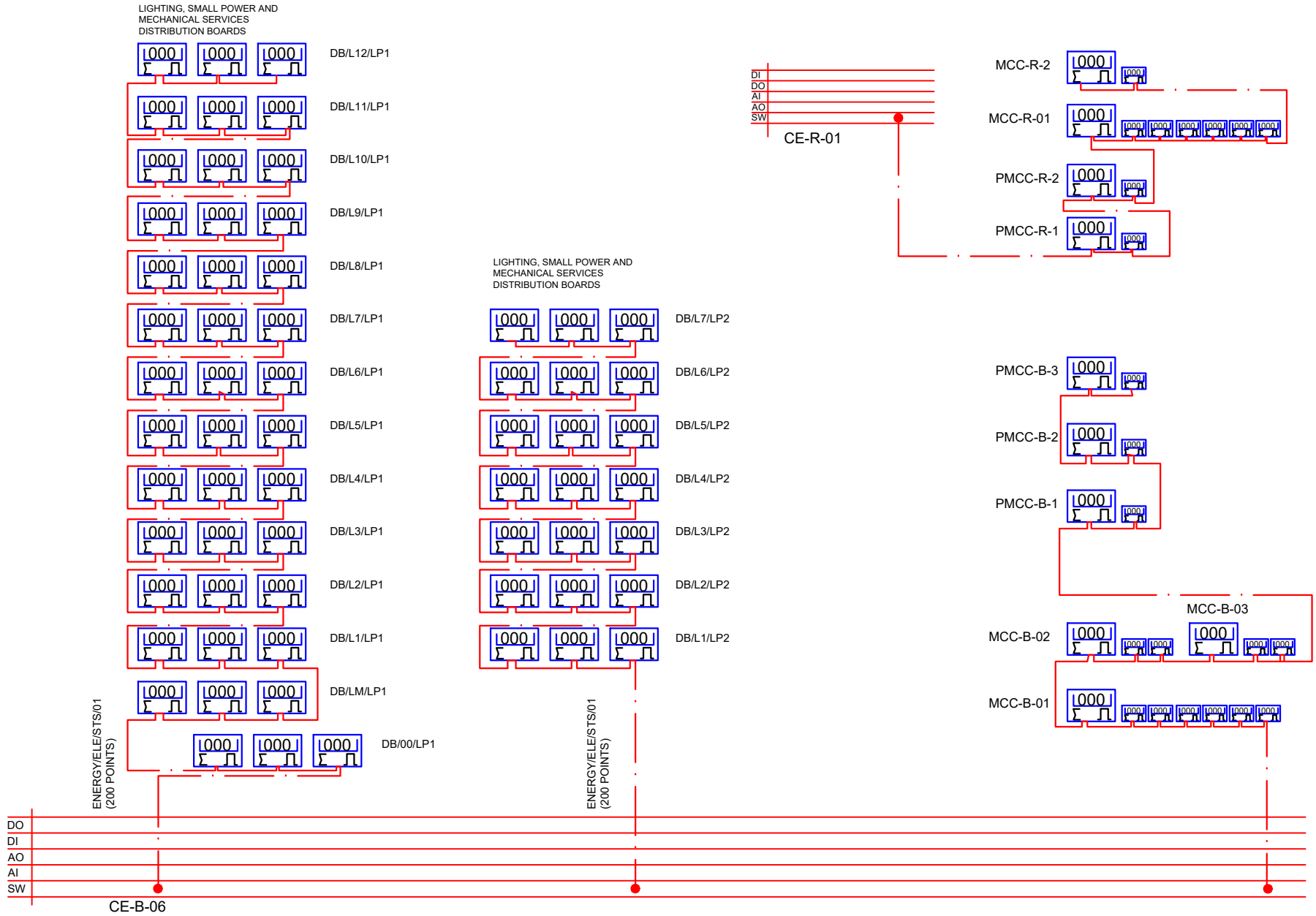
Scales @ A3

Work to figured dimensions only

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 8010

Revision: C-01



SERVICES PROVIDED BY THE BMS SPECIALIST

SERVICES PROVIDED BY THE MEP SPECIALIST

Rev	Date	Description	By
		Amendments	

PRINT IN COLOUR | GENERAL NOTES

FAIRLAWN CONTROLS

Project: OCT 2022

Title: AUTOMATIC CONTROLS
ELECTRICAL MONITORING 2

Client:

Drawing Status

Designed by: Alan Jones

Drawn by: Alan Jones

Date: 10-10-2021

Scales @ A3
Work to figured dimensions only

Project no.

Computer file No.

Project - Originator - Volume- level - Type - Role - Number: 8020

Revision: C-01