Facilities, Residential and Commercial Services

BEMS Design Requirements & Specification

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A (1.1)	23 Apr 2021	Update following internal review meetings and emails 29Jan to 08 Feb 2021.
B (1.2)	05 May 2021	FM00144 assigned to this document. No other revisions.

1.0 University of Liverpool – BEMS Design Requirement & Specification

1.1 This document to act as both design requirement and specification for installation, modification and commissioning of Building Energy Management Systems (BEMS) at the University of Liverpool (UoL). It is split into two parts.

1.2 Part A covers the general requirements and process for design, approval, installation and commissioning.

1.3 Part B covers specific requirements for certain equipment or systems where these are known and defined.

1.4 Both sections are new (2021) and will be subject to regular review and update. Therefore ensure a check occurs that an updated version has not been issued and ensure that the basis of the design is compliant with the current version available at that stage of design.

1.5 There will be situations that the requirements of this document are not practical, sensible or warranted; therefore where issues may exist then they should be raised at the earliest opportunity with details allowing assessment and possible change as either a derogation at design stage or as a Compensation Event at construction stage. However this document should be adhered to till the derogation and any alternative arrangement confirmed in writing or CE issued.

PART A – General Requirements for Design, Approval, Installation & Commissioning

2.0 BEMS Scope

2.1 The control of building services is required for both correct operation and to achieve the required environmental conditions and energy performance. Therefore any system intended to control the space temperature, ventilation or domestic water is to be controlled and monitored by the UoL BEMS.

2.2 UoL policy is for direct control and monitoring via the BEMS but due to the use of packaged plant and special systems the actual control may need to remain as part of the packaged plant or systems. However they need to be connected to the BEMS so that key settings, monitoring of readings and alarm monitoring is via the BEMS as if they were controlled directly by the BEMS.

2.3 Where this is not sensible or practical then it will need to be treated as a derogation and this confirmed in writing via the Senior Mechanical Engineer.

3.0 BEMS System

3.1 To be based on local panels using a Tridium JACE with suitable interface modules to components and local interface with associated equipment.

3.2 To be integrated onto the existing Tridium N4 Niagara Supervisor system (N4) housed on the UoL intranet and be complete with Front End Graphics (FEG) and alarm handling installed as per the requirements of the FRCS BEMS Manager and the UoL N4 Supervisor Set Up Requirements

3.3 To be tested to prove that the BEMS system has been fully commissioned as part of any installation or alterations works.

3.4 All work to install or modify the BEMS (panel, field devices, FEG, N4 Setup, commissioning) to be carried out by a specialist BEMS contractor as per the UoL Approved List of BEMS Contractors.

3.5 All equipment installed as part of the BEMs to be as per the Approved Equipment Manufacturers List – Mechanical (Appendix 2 of the UoL Mechanical Design Requirement).

4.0 Panels & Field Wiring – New Systems (Blank Facia)

4.1 New systems are to comprise of BEMS ELV panel that houses the Tridium JACE along with input/output interfaces, relays, control cards and power supply unit (PSU). Other than the supply to the PSU everything in this should be ELV (<50v) or have a notional rating of 24v (AC or DC) or less.

4.2 The JACE to be supplied with a licence that extends at least 9 months past the date of Taking Over (Practical Completion) for that area of works that that BEMS panel is part of.

4.3 Other than panel live lamps, identification label, warning labels and quarter turn service panel locks the facia of the panel should be blank (hence Blank Facia).

4.4 BEMS ELV panels to be located in plant rooms so secure, dry well lit and accessible.

4.5 BEMS ELV panels to arranged, sized and located to suit the installation and level of resilience warranted by the facility. Several medium sized panels are preferred to one very large panel.

4.6 Every BEMS ELV panel should have a dedicated JACE and dual data connection point. Where it is considered sensible to utilise satellite panels whether adjacent or remote then this will need to be agreed in advance and covered by a derogation; therefore they are not allowed till confirmed otherwise.

4.7 Meters, lighting control and monitoring systems etc. should not be connected to the BEMS JACE but utilise a dedicated Automated Monitoring and Targeting (aM&T) JACE, enclosure and data connection. The necessary energy consumption figures to be displayed on the BEMS to be obtained by interface with the aM&T system and not direct from the meter.

4.8 The panel to be powder coated metal with a hinged door secured by panel locks. Panels should be at least IP4X rated and located inside plant rooms.

4.9 The LV for all equipment controlled by the BEMS ELV panel to be taken from a dedicated LV Distribution Boards (DB). These DBs to be to the same standard as per the UoL Electrical Specification. They should be referenced to match the BEMS ELV panel and located adjacent he BEMS ELV panel whenever possible. The supply to these DBs needs to be metered.

4.10 Other than network cables for MODBUS and BACNET interfaces all devices remote from the panels are to be connected by dedicated cables from the ELV or LV DB.

4.11 Any interlocks are to be via relays in the ELV panel. Daisy chaining of control logic via field devices is not allowed. Cables from relays, contacts or switches in remote monitored devices to operate a relay with interface with the BEMS. Unless stated otherwise all interlocks to be hard wired fail safe so that a loss of power, disconnection of cable or fault results in shutdown of that interlocked item.

4.12 All cabling in the panel to be LSOH, neat, contained via a cable management system, colour coded and identified at each end via unique reference ferrules. A numbered terminal rail to be used to connect all field cables to internal panel cables.

4.13 All devices in the ELV panel to be labelled. This includes the JACE, every input/output module, relay, fuse, MCB, contactor, control card etc. A laminated schedule confirmed what every device is with relevant information such as rating for fuses or description for relays to be secured inside the panel. A copy of the latest panel wiring diagrams to be located in the panel.

4.14 Relays are to have a lift up lever (orange flag) to allow the relay to be over-ridden manually. The lever to be obvious when over-ridden and all relays positioned so visible.

4.15 Where contactors are required to directly switch on and off devices (traditional pumps or fan motors) then they are to be housed in IP54 enclosures and located near to the device controlled. The need to be clearly labelled with both the DB Cct reference and the control item reference.

4.16 Lockable isolators to be located adjacent all equipment supplied with LV. They need to be labelled with both the DB Cct reference and the control item reference.

4.17 All wiring and installation to both LV and ELV to be in accordance with the UoL Electrical Specification.

4.18 The LV and ELV cabling to utilise separate containment systems.

4.19 If a local isolator for the supply to the PSU in the BEMS ELV panel is deemed necessary then it is to be located inside the BEMS ELV panel and clearly labelled. If it is deemed necessary for a facia mounted interlocked isolator to be used then it must a defeatable type allowing the panel to be opened via special tool without having to isolate the power.

4.20 The supply for the BEMS ELV panel is to be a dedicated circuit with no other connections.

4.21 A dual data point should be located above the BEMS ELV panel with a suitable connection lead routed via a sealed cable gland. One port is for the connection of the JACE while the other is for laptop to allow verification of the FEG on the N4.

4.22 A twin 13A switched socket outlet with integral RCD protection supplied by a MCB in the DB should be located under or adjacent the BEMS ELV panel for use of the laptop. This is to be on a separate circuit from that used for the BEMS ELV panel.

5.0 Modifications To Existing ELV (Blank Facia) Panel Systems

5.1 This covers existing BEMS panels that are generally as described for New Systems (blank facia ELV panel with dedicated LV DB).

5.2 These panels should be modified and refurbished so to be fully compliant with the New System as detailed above. All new sections or modified parts of the existing system to be brought upto the standards as required for new installations.

5.3 A review of all existing parts of the system to take place at design stage and a decision over what can remain as is and what should be brought up to the standard for new installations made clear. The minimum expectation is that any equipment or system being refurbished, re-commissioned, modified or control requirements changed should have all of the associated BEMS part brought up to the standard as if new.

6.0 Modified Existing Conventional Control Panel Systems

6.1 Where it has been agreed that an existing control panel is to be retained it is to be refurbished and modified as detailed in a separate document. To avoid doubt assume that the existing is to be replaced with a New System till it is agreed in writing that the existing can be retained and refurbished.

6.2 This covers panels that contain both ELV and LV in the same enclosure and applies whether the sections are segregated or not. These panels normally have controllers, input/output cards, relays, contactors, fuses/MCBs, contactors, starters, inverters, PSU and normally with indictor lamps and hand/off/auto switches on the panel fascia.

6.3 Refer to the UoL FRCS ESG Senior Mechanical Engineer for details of the Modification of Existing Conventional Control Panel Systems document.

7.0 N4 Setup

7.1 The existing site wide Tridium Niagara N4 Supervisor (N4 Supervisor) system will need to be modified to integrate the new panel and system complete with new Front End Graphics (FEG), time clock, alarm handling and meter information.

7.2 The required file set up, naming conventions, graphics need to be in accordance with the N4 Supervisor Setup Standard as managed by the UoL BEMS Manager.

7.3 All key operational data needs to be provided via the UoL PM to the UoL BEMS Manager prior to Taking Over. This includes but not limited to:

JACE MAC Address

Assigned IP address used by the JACE

JACE licence details and QNX number

Confirmation that LAN2 on the JACE is the default IP address (and what this is)

Panel drawings – of the finished installation as both PDF and ACAD drg file

Schedule of all relays, fuses, controllers etc. located in the panel.

Schedule of all devices on the MODBUS, MBUS or BACNET networks connected to the JACE including location (PLANON Space Ref), type, address etc. along with a description stating what it is.

Software backup of the panel installation (station copy of the JACE) and relevant graphic pages and files on the N4 – on a labelled USB drive.

7.4 Work on the N4 Supervisor is a specialised task and as this system manages all heating, ventilation, cooling and domestic water plant in all the buildings across all of the UoL estate it needs to be managed to avoid disruption to any existing system.

7.5 The contract is to include that the BEMS specialist contractor installing or modifying the BEMS panel or system also integrates and updates the N4 Supervisor. The BEMS specialist contractor will need to liaise with the UoL BEMS Manager and the UoL PM from an early stage of the project to ensure they have the necessary information access rights and authorisation for both the UoL intranet system and the N4 Supervisor.

7.6 Until the BEMS Manager confirms that specific named operatives can work un-supervised on the N4 Supervisor they will only be able to work on the N4 Supervisor when the BEMS Manager is on site and can monitor and supervise their work. Generally this will apply to new operatives or organisations who have not worked on the UoL N4 Supervisor previously and be applicable for the first three systems they set up. Therefore adequate planning and notice should be made for arranging supervised access to the N4 Supervisor.

7.7 As the setup and alteration of the N4 Supervisor is a specialised task only certain operatives or organisations can check and verify if this is complete and correct. While the responsibility for this check is with the UoL BEMS Manager they may not have the time or resources, therefore they may delegate this task to a third party, normally the specialist BEMS contractor engaged to maintain and backupthe N4 Supervisor Set Up. Where this occurs the costs will be expected to be funded from the overall project cost centre as a Supervisor fee and is not to form part of the contract works. Verification that the N4 Supervisor has been set up will be requested during the commissioning stage and this either confirmed or a list of defects issued that need to be corrected and this process repeated till it is correct.

7.8 It should be noted that if issues occur with the work to the N4 Supervisor Set Up that jeopardises the overall UoL BEMS system, causes operational issues in this or other UoL facilities then the UoL reserves the right to remove access rights from the BEMS specialist contractor without notice. And where acceptable remedial measures or notified defects are not implemented in the required timescale, and subject to the form of contract being used, that the issue will be treated as a defect such that other suitable BEMs contractors will be appointed to correct and complete this element of work to the required standard and with all associated and substantiated costs deducted from the contract sum.

8.0 FEG - Front End Graphics

8.1 Front End Graphics are to be set up to show all equipment, set points, key calculated set points and status of all control items and equipment controlled.

8.2 The graphics should be drawn using the standard N4 graphics and as detailed in the N4 Supervisor Setup Standard. Proprietary or third party graphic packages are not to be used.

8.3 All sensors, meters etc. should be graphable. When clicked on a graph showing the readings for the last week to be displayed as a pop up window on top of the FEG page. The sampling should be based on the accuracy of control but generally should be recorded every 5 minutes and retained for 3 months.

8.4 All inputs relating to plant or equipment status including all associated with interlocks to be displayed as an OK(green)/FAULT(orange)/FAIL(red) or OFF(grey) flag on the appropriate FEG plant schematic page.

8.5 All set points should be adjustable by the FEG. On more complex systems while these set point may need to be on and adjusted via a separate page the key operational set points should be displayed against the relevant plant schematic (frost coil set point shown adjacent the frost coil alongside the actual off coil temperature).

8.6 Where building users need to access the FEG to change time clock settings or check that the plant is working as it should there should be a dedicated page with the details and set points that they need. Typically this is time clock, average internal temperature, any relevant set point, external air temp, plant status and possibly certain alarms. This so that building users can access what they need without giving full access and the need to restrict what certain users can change or view.

8.7 The FEG to use the same referencing as used by the plant labelling and be based on the plant schematic.

8.8 The FEG for each system to have a front page with agreed system name and links back to the relevant campus map page, notes giving basic system details such as where it is and what it does with a link to all other pages that detail each main system and/or area of the building. Every page should display the system name and relevant plant name and reference number. The page hierarchy should be obvious so all pages are obvious and consistent with direct links back to their associated system page, front page and N4 Supervisor Site Map.

8.9 The FEG will normally have a page(s) for each system, item of equipment with separate pages for set points, system notes as relevant. Where a system controls a room or a number of rooms then a page for showing how each space is being controlled and status of the controlled services for that room. So an AHU serving a Lecture Theatre may have 4 pages, one of the AHU, one for set points, one of system notes summarising key information and a page of the space showing room conditions, supply air temp, radiator zone valve status, plant status etc.

8.10 Any output, set point, status or value that has been over ridden is to have the associated display box coloured purple so it is obvious that this has been over ridden.

8.11 Draft FEG should be submitted for comment and approval at an early stage of the project, and before the panel is constructed and software written.

9.0 Alarms

9.1 Key alarms should be set up so visible on a dedicated Alarm page with text, time stamp etc. and with a simple OK(Green)/Alarm(Red) status on the relevant FEG plant schematic page. There are three main categories of alarms.

9.2 Category 1 Alarm – Critical – As in it will warrant a call out 24/7/365 and where failure will result in significant disruption or damage. Any normally operational plant that is monitored should be n+1 resilient arrangement and capacity, or with a manually configurable replacement system available or an emergency action defined. If it hasn't then it doesn't need a Category 1 alarm. The alarm should be generated at the JACE and interface with the UoL Site Wide PATRIOT alarm handling system via a local dedicated dual communication systems back to a 24/7 on-site response centre (Campus Support office). As such the required actions of the Campus Support staff and who they contact and what the people contacted then need to do needs to be defined in writing, this approved and issued prior to setting up the alarm.

9.3 Category 2 Alarm – Significant – As in it while it may not always warrant a 24/7/365 call out it would be expected that attendance that working day or start of the next day to correct. And where a situation is developing that would invariably result in a Cat 1 alarm occurring. Alarm interface would be via email to either FRCS or the Users. The message needs to be clear what it relates to and the necessary actions obvious or defined in writing, approved and issued prior to setting up the alarm.

9.4 Category 3 Alarm – General – Most plant fault condition such as dirty filter or duty pump failed (and stand-by running). Displayed as a FAULT (red) /OK (green) flag on the FEG plant schematic page.

9.5 The BEMS is not to be used for alarm handling of other systems as it is not deemed a resilient system. These other alarms should either go direct to the PATRIOT system, via the aM&T system or an alternative alarm communication system.

9.6 All categories of BEMS alarm to be displayed on the Alarm page of the FEG for that system and be available for display on any campus wide alarm page.

9.7 The use of Category 1 and 2 alarms should be minimised. They should not be a default option and only set up if warranted and confirmed as necessary by those responding. They will need to be proven and witnessed as part of the commissioning and handover process.

9.8 Plant alarm interface. Due to problems with plant fault reporting via MODBUS and BACNET communications (they do not transmit a fault signal when internal or external power faults occur and for various other reasons) all such plant should be provided with a Normally Open Volt Free Contact relay (NO VFC) that is closed by the plant if the plant is OK. This to be connected as hard wired OK/FAULT status to the BEMS.

10.0 DesOps – Description of Operations

10.1 A summary of how the plant is to operate to achieve the required environmental conditions and other operational requirements is to be provided by the design engineer. While this can subsequently be developed by the specialist BEMS contractor the DesOps needs to clarifying how the plant operates and needs to be defined by the same person who has designed the plant or system. This to cover both environmental criteria, H&S interlocks, plant protection interlocks, Category 1 and 2 alarms, plant set back, shutdown and frost protection.

10.2 The DesOps should be issued at each design stage. It should be developed and expanded as the scheme progresses through each design stage and reflect the associated level of design detail required at that the relevant RIBA stage of work.

10.3 There should be plant and system schematics produced as part of the overall design and the DesOps and these schematics should be developed and reviewed together.

11.0 Control Items – General Requirements

11.1 Every project is different and the scope and requirements will need to be defined as part of the design process. Therefore what follows is generic requirement of what should be provided except where detailed in Part B – Specific Requirements For Equipment Or Systems.

11.2 A schematic to be provided showing all equipment or devices that are associated with the heating, cooling, domestic water, ventilation systems or other mechanical services forming part of the project.

11.3 This schematic to show all control items that control or monitor this equipment and systems associated with heating, cooling or ventilation systems or other mechanical services forming part of the project and should be provided at an early stage of design. All key items of equipment on this schematic are to be referenced as per the UoL – ESG, RCS – Mech Abbreviation Codes for Schematics and Identification.

11.4 Sensors are required to monitor the temperature either side of any equipment that transfers heat and in systems that convey heat or cooling to or from a space or area. So temperature sensors are required before and after every heating coil, heat recovery device and in both the supply and return air ducts from main plant. Temperature sensors are required in the common return to boilers and in the flow from each boiler as well as the common flow circuit. Where mixing or control valves are used then sensors required in the flow pipework after the mixing valve and in the associated return circuit.

11.5 Pressure transducers are required across every ventilation filter to monitor filter condition and in the main supply and extract duct to monitor the duct static pressure.

11.6 Any space or area that has both heating and cooling (including via mechanical ventilation and automated natural ventilation) to be controlled and monitored by the BEMS and to ensure that heating and cooling can not occur at the same time.

11.7 Any space or area that has heating or cooling (including via mechanical ventilation and automated natural ventilation) has control and monitoring via the BEMS so that the heating and cooling set points and environmental conditions can be set and monitored so to be as per the UoL Energy Requirements. And where alternative local environmental conditions have been agreed and confirmed as necessary that these can be controlled and monitored via the BEMS.

11.8 That the operation of heating, cooling and ventilation systems is controlled and monitored by the BEMS so that the space or areas are heated, cooled and ventilated as required when occupied and that these systems shut down or set back as appropriate to minimise energy consumption when not occupied.

11.9 That plant status conditions relating to H&S issues and key functional performance issues are visible, monitored and recorded by the BEMS.

11.10 That the necessary plant control, sequencing and equipment interlocks to operate and prevent damage are provided by or monitored and visible by the BEMS.

11.11 That key energy consumption figures are monitored and recorded to verify that the plant is operating efficiently and to allow basic Monitoring and Targeting of energy consumption.

11.12 Wall mounted temperature sensors are to be used in all rooms with local controlled heating via control valves or cooling (VRV, split, fan coil, CRAC, radiant panel, chilled beams, ventilation or automated natural ventilation openings). Rooms larger than 50m2 should have at least 2 such sensors with basis being at least one sensor for every 50m2. Where close control temperature (with a control of +/-1^{o}C) or a large change in usage such as lecture theatres or teaching spaces then the number of sensors should be doubled.

11.13 CO2 sensors should be used in all rooms with local demand controlled ventilation (fan speed, air valve, motorised damper or automated windows) and in the return air ducts of ventilation systems where the fan speeds, air flow rate or pressures are variable based on either demand control or occupation.

11.14 All sensors, calculated set points and user interfaces (local on/off, set point or PIR active) should be logged. The sampling period should be agreed at an early stage of the approval process but as indication the expectation is that all sensors are logged every 5 minutes and records kept for 3 months.

11.15 All sensors must be capable of being accessible and removable from ductwork, pipework or AHUs for inspection and maintenance purposes without removal of ductwork, pipework or thermal insulation. Sensors should be located outside of AHUs so they can checked and replaced without having to shut down or open up the AHU.

12.0 Design Approval & BEMS Set Up Process

12.1 Recurring and avoidable issues with the setup of the BEMS are resulting in significant delays and operational problems on a number of projects and with the resultant impact on the use of facilities. Therefore the following approach is to be utilised to minimise this.

12.2 At each key design stage a schematic of the plant and system to be provided complete with all relevant control items. This to be submitted with the DesOps at each RIBA Stage Review. Both to be of the expected detail associated with that RIBA Stage; as in starting as simple outline proposal and with increased level of detail and clarity at each design stage. The associated environmental criteria should be stated at each stage. A review to occur to check what is proposed is sensible and plausible and to identify any key test criteria or operational limitations.

12.3 At early stage of construction stage a review of the schematic and designers DesOps to take place with the appointed BEMS specialist contractor, the designer and the UoL PM. Any issues or concerns to be raised and resolved.

12.4 Any stage 1 or 2 alarms deemed necessary to be confirmed with the UoL PM along with the criteria, means of communicating, who to, required response and actions to occur to be defined and issued.

12.5 Any access rights, permissions, validation checks to be completed and verified so that the BEMS specialist contractor can access both the UoL data network and work on the set up and modification of the N4 Supervisor. If the BEMS specialist is unable to comply with the UoL requirements then they need to be replaced.

12.6 Draft FEG pages to be submitted along with an updated DesOps by the BEMS specialist contractor for comment and review at an early stage of construction. These are to be commented on, updated and this repeated till approved. The plant schematic to be updated and re-issued as part of this. The identification of all plant and control items should be on the schematic and in accordance with the Labelling requirements. This process should be completed before control panel drawings are submitted for review and that the control panel drawings utilise the correct reference and match the schematic.

12.7 Control panel drawings can be submitted for comment and approval. These are to be checked to ensure that every device on the schematics is present on the control panel drawing and that the referencing matches.

12.8 The control software and logic programmes to be written and based on the approved panel drawings, the approved FEG and the approved DesOps.

12.9 The data point should be installed and made live at earliest opportunity. Where this will not be live by the time the panel is on site the contractor is to arrange for either a suitable temporary data connection back to the UoL N4 Supervisor or where accepted that this is not practical provide a dummy front end N4 set up via temporary PC or laptop.

12.10 The MAC address should be confirmed along with data point address via the UoL PM so that the necessary panel ID set up by CSD (static IP address) can be completed. On schemes where the contractual arrangement is that the contractor liaises directly with CSD they need to keep the UoL PM informed and aware of what issued and when.

12.11 The FEG should be uploaded to the N4 Supervisor and basic file structures set up. While the sensors and values will initially be blank they will be made live as systems are commissioned allowing visibility at an early stage. This is imperative where the proposed works impact on existing live systems, are interfacing with existing systems or services and reduces the time to check and verify.

12.12 The panel should be installed, field wiring completed and terminated, dead tested and point to point tested, with the field device labelled as each point to point test is completed.

12.13 The JACE should be set up and interfaced with the N4 Supervisor.

12.14 The software and logic programme for the panel should be uploaded and the initial BEMS commissioning completed. As each component and device is made operational the associated FEG links should be updated so it is visible.

12.15 The contractor should progress the installation and operational checks with regular updates on progress and with a status log of any issues noted that is updated as items resolved. This status log to help ensure that issues outside of the control of the BEMS installer are not left ignored or missed, especially where interlocks are frigged out or settings or outputs over ridden to allow commissioning to progress.

12.16 When the system commissioning is complete the BEMS contractor is to check and ensure that all items are complete and correct before offering the system up for validation checks with the UoL PM/Design Consultant and Supervisor. Where minor items are still in progress or known issues exist then these should all be on the status log.

12.17 It the status log is too long or FEG incomplete then the system will be rejected and Validation Checks will not commence. If a significant number of defects or issues are discovered during the Validation checks then the system will be rejected and Validation checks cease. The Contractor will then need to repeat their checks and ensure that the system is complete and commissioned before offering it up with an updated status log for Validation. This process to repeat till the system is proven to be complete bar for a few minor items that can be treated as defects and that do not impact on the ability to use the facility safely and can be corrected with minimal disruption.

12.18 Following the Validation Checks there will normally be a number of Operational & Performance Checks prior to Taking Over and post Taking Over.

12.19 The BEMS contractor and Main/Mechanical Contractor to be present throughout these Validation Checks and to be managing and implementing the test process including adjustment, isolations, disconnections etc. in order to create the various test scenarios. They are to remain involved in the subsequent Operational & Performance Checks.

12.20 To avoid confusion the following commissioning stages should be used when reporting progress and to help clarify what is expected.

12.21 BEMS Commissioning Stage 1 – All cabling installed, dead tests and point to point tests completed and all field devices installed and correctly labelled with at least SAV labels.

12.22 BEMS Commissioning Stage 2 – All plant connected and under control of the BEMS (fans running correctly and under speed control, pumps running correctly, fault changeover working, fault monitoring and interlocks proven). This is normally required to allow the flow rate and other commissioning of the mechanical services to progress.

12.23 BEMS Commissioning Stage 3 – The FEG and control software is complete, working correctly and has been checked by the BEMS Specialist Contractor and Main/Mechanical Contractor.

12.24 Validation Checks – The BEMS system to be offered up for review and demonstration to the UoL PM, design consultants and appointed contract Supervisor. A sample of all relevant checks to be carried out at random. All key system checks that relate to H&S or plant protection as well as all Category 1 & 2 alarms are to proven to be correct, witnessed and recorded. Taking Over (or Practical Completion) can not be considered unless this has been completed.

12.25 N4 Supervisor Set Up Checks – confirmation from the BEMS Manager that this has been completed, is correct and that all necessary information has been provided, or where minor items are outstanding that they have been identified and are being treated as a defect.

12.26 Operational & Performance Checks – Pre Taking Over – This covers key system performance checks relating to the control and performance of an overall system rather than just the BEMS. This is more relevant where design and build has occurred but also relevant to prove the correct operation, set up and commissioning of the entire installation. This will entail temperature stability checks, response to set point changes, set back and on/off operation, automatic plant rotation, pressure stability checks, response to changes in heat load and meter readings. Where specific performance checks are required that need dummy heat loads or close control criteria are required then the basis and means of testing needs to be defined at the earliest stage practical and the basis of testing and temporary equipment made clear.

12.27 Operational Review – Post Taking Over – This covers the ongoing system performance checks that need time to complete and could not be completed prior to Taking Over. The basis of this is not to be based on the outstanding tests but on tests that cannot reasonably be completed prior due to lack of occupation loads, weather conditions or where the original contract period could never have accommodated such tests. The typical example is demand driven ventilation based on occupation or frost control and protection checks when commissioned in summer. That the test may have been completed via temporary set point or dummy load does not remove the need for the test to be completed in real world conditions and any such test failure will be treated as a defect.

12.28 If issues occur with the work to the N4 Supervisor that jeopardises the overall UoL BEMS system or causes operational issues in other UoL facilities, then the UoL reserves the right to remove access rights from the BEMS specialist contractor without notice. And where acceptable remedial measures are not implemented in the required timescale, and subject to the form of contract being used, that the issue will be treated as a defect such that others may be appointed to correct and complete this element of work to the required standard and where possible that all associated and substantiated costs deducted from the contract sum.

12.29 The Main Contractor and their Mechanical sub-contractor should be in attendance at all meetings and party to all communication with the BEMS specialist contractor.

13.0 Labelling – Control Items

13.1 This covers both physical labelling of equipment and control items and the related software label (or point description) assigned to control items.

13.2 All sensors and similar control items to have a unique reference assigned to be based on the UoL Mechanical Plant Abbreviation Codes for Schematics and as per the N4 Supervisor Setup Standard. This uses the format of Plant Ref then Control Item and then a Description to clearly identify. This reference to be applied to the panel drawings and software label (or point description).

13.3 So the full reference for the frost coil temperature sensor on AHU 901-01 is AHU/901-01-TS-HBFr where:

AHU indicates it is part of an AHU

901 indicates it is located in Building 901 and uses the established building number system.

01 indicates it is AHU 901-01

TS – Indicates it is a temperature sensor

HBFr indicates it is the temperature sensor associated with the frost coil (Heater Battery Frost)

13.4 A physical label to be fitted on site matching the reference. Where this is obvious what it relates then the physical label can be reduced in length. So while the full reference for the frost coil temperature sensor on AHU/901-01 is AHU/901-01-TS-HB-Fr this can be reduced to TS-FB-Fr for the physical label as long as there is a main plant label visible on the AHU that makes it clear it is AHU/901-01. All remote control items not located on or directly adjacent the AHU need to have the full reference.

13.5 Labels are to be both Self Adhesive Vinyl (SAV) and Traffolite. SAV to be 6mm high black text on Brother TZe Strong Adhesive Laminated white tape, cut neatly and applied to a clean, dry and degreased surface as the system is installed. All equipment and control items need to be correctly identified at the earliest opportunity and before the system is commissioned (BEMS Commissioning Sage 1). A schedule of labels as fitted to be kept and used to order engraved traffolite labels with 6mm black text onto a white background. The traffolite labels to be fitted adjacent to the SAV label with suitable sealed mechanical fixings where possible or attached by stainless steel chain where the mechanical fixing will reduce the weather integrity of the control item.

13.6 Labelling is required prior to commissioning and system proving tests; there should be no ambiguity over what each device is meant to be doing and called during any stage of commissioning from pre-commissioning onwards. If the SAV label is wrong then it needs to be changed as and when noted and the schedule of traffolite labels updated. There is to be no ambiguity over what has been tested, what is still to be tested and which items need remedial actions.

14.0 Labelling – LV Items & Equipment

14.1 Equipment is to be labelled with both the equipment reference, the associated DB/Cct reference and a general description label of what the equipment is and does as relevant.

14.2 Electrical isolators associated with the equipment are to be labelled with both the equipment reference as used by BEMS (and on the schematic) and the associated DB/Cct reference.

14.3 The LV distribution schedule should include the relevant equipment reference.

14.4 The MCB circuit number should be marked against each MCB with neat SAV labelling.

14.5 A random selection of circuits will be tested at validation stage.

14.6 The actual labelling to be as per the ELV section.

15.0 System Proving Checks & Validation

15.1 The contractor is to ensure that the system is working correctly and ensure that the various system checks have been completed and FEG fully set up correctly before offering the system up to the UoL PM for Validation.

15.2 Any issues in the set up should be raised as soon as this becomes apparent (and no later than the first working day after first noted) to the UoL PM with details of what, why and what action is proposed to correct.

15.3 Once it is fully set up then the system to be offered for validation with the UoL PM or appointed Supervisor so they can carry out spot checks on the system with the BEMS contractor present.

15.4 The following is only an outline indication of typical tests.

Temperature set point adjustment and stable temperature control.

Fan speed adjustment or stable fan speed control where demand driven.

All safety interlocks, plant protection interlocks or operational sequencing and changeover proven and witnessed.

FAI interface shutdown and correct re-start proven and witnessed.

All Category 1 & 2 alarms proven and witnessed with written confirmation that the correct signal was received at the correct location.

All category 3 alarms checked.

Time clock change of temperature and fan speed where set back conditions exist or on off control exists.

Frost protection measures proven and witnessed.

Local user control interface and PIR auto set back tested.

Green/Red FEG conditions proven including all air flow proving, filter dirty etc.

Correct matching, referencing, reading and graphing of all the pressure transducers.

Correct matching, referencing, reading and graphing of temperature sensors.

Black start (automatic re-start following sudden loss and reinstatement of LV power) proven and witnessed.

15.5 Where tests are noted as to be proven and witnessed then these should be proven by the contractor and witnessed by the UoL PM, UoL Appointed Design Consultant, NEC Supervisor or CoW with a record issued of what tested, how, what was proven, when and whether the test was successful and complete. These tests can occur either when the Contractor is testing or at the Validation stage as long as they do occur and a record exists that they all worked. Where subsequent alterations occur then tests may need to be repeated. Where tests are partially proven then they should be repeated. And it should be noted that the test is that the entire system does what it should and not just that the BEMS part is working.

15.6 The testing will be by FEG set point adjustment, on site filter removal, isolation of supplies or local removal or disconnection.

15.7 Should a significant number of tests fail or the system clearly not fully set up then the Validation testing will be cancelled and the contractor left to correct and ensure that all is correct before offering it back up. Failure to have the system Validated will prevent completion. It is the Contractor's responsibility to set up the system correctly and carry out testing to prove it is, before offering the system up for Validation.

15.8 At the UoL PMs discretion a few minor issues can be treated as post completion defects; but only if it does not impact the safe and effective use of the facility and that it is practical to correct the defect with minimal and acceptable disruption post Taking Over.

15.9 Some stability and plant rotation tests will need the system to be left operationally and will be monitored by the UoL PM or Supervisor via the N4. These may take several week to be fully completed and all issues noted with these tests to be treated as defects.

16.0 Seasonal Commissioning and System Maintenance

16.1 The contractor should include for a remote diagnostic review of the system operating characteristics and minor modifications of the FEG to suit the UoL PM. This should occur between 4 and 6 weeks after completion and again 5 to 6 months after completion.

16.2 A full on-site system check to take place between 11 and 12 months after completion. The contractor to check the installation, verify the correct operation of all control items, check set points and adjust settings and minor FEG to suit the UoL PM. Any device that was retained and re-used that has failed to have a quotation submitted for replacement. Any device that was new but has failed will need to be replaced as a defect by the contractor under warranty.

16.3 A report to be submitted after each review or system check confirming what was tested, reviewed, adjusted or replaced along with any recommendations or further remedial work required.

16.4 It should be noted that the above does not remove or extend the period in which the contractor needs to have corrected any notified defects.

PART B – Specific Requirements for Equipment or Systems

17.0 Control Items - Specific Requirements

17.1 Part A included a high level general description and basis of control items required. This section provides details on the control items, FEG, set up and installation requirements for specific systems or equipment. If it is not covered by this section then follow the Control Item General Requirements in Part A till detailed and agreed by the DesOps, schematic and approved FEG.

18.0 Filters

18.1 Pressure transducers required across any filter installed in ventilation plant or equipment other than washable types installed in VRV and split cassette systems. Monitoring of the filter condition as a CLEAN/DIRTY (Green/Red) flag on the FEG with adjustable dirty filter set point on the FEG. The alarm is latch on if the set point is exceeded for more than 30s and remain on until a reset button on the FEG is pressed. These alarms are normally a Category 3 alarm.

18.2 There should be notes on the FEG confirming the filter dirty pressure drop condition; these should be as per the AHU manufacturers design details.

19.0 AHU Duct Static Pressure – Airflow OK Monitoring

19.1 All air handling units, heat recovery units and extract fans (other than wall or window mounted units that are visible and under local control or fume cupboard extract fans that serve only one fume cupboard) are to have pressure transducers fitted in the supply duct to the occupied space and extract ducts from the occupied space. These are to monitor the duct static pressure and required to help verify that the air flow rate is OK.

19.2 An Airflow OK/FAILED (Green/Red) flag with set point to be on the FEG along with a Duct Static OK/Low (Green/Red) with set point on the FEG. The duct static and fan speed at both maximum and minimum design duty as recorded when the system commissioned to be stated as a note on the FEG.

19.3 The Airflow OK set point to be typically 50% of the duct static at minimum fan speed.

19.4 The Duct Static OK to be set at 90% of the duct static at minimum fan speed. Note that FRCS Staff will alter settings to bring the fan speed back to design maximum condition and verify the duct static reading against that expected on a regular basis.

19.5 These alarms are not to latch and should have a 15s delay before triggering fault. These alarms will normally be a Category 3 alarm but there may be a few specialised systems that require a Cat 1 or 2 alarm.

19.6 The above is to allow monitoring and remote verification of ventilation systems controlled to either fixed supply rate or demand driven ventilation (CO2, temperature, occupancy). The pressure transducer in the duct does not signify direct control of the fan speed to maintain a duct static pressure.

19.7 Where a system has a duct pressure control strategy they will be clearly identified as such and will have separate set points for duct static (day and night), high and low alarm pressure alarms (day and night), and min and max fan speeds.

20.0 VRV & Split System

20.1 Where VRV or split systems (including VRF, multi-split and other variants) are used then they need to be interfaced with the BEMS.

20.2 Wall mounted control units should not be installed in the room served by the VRV cassette or split. Where local control panels are required for system set up and maintenance checks then they need to be located in a plant room or plant service cupboard. They need to be labelled with the system/cassette reference and that they are under BEMS control.

20.3 A fault Volt Free Contact to be provided in the ACCU and where possible in every cassette (other than single cassette split systems) as part of the VRV or split system. This to show as an OK/FAULT on the BEMS FEG.

20.4 The BEMS to interface with the VRV or split by a suitable MODBUS or BACNET interface card supplied as part of the VRV or split system. The BEMS to have control of the set point for heating, cooling (and/or dead band), mode of operation, fan speed and louvre position as well as on/off (via a 7day time clock). The dirty filter condition and system fault code should be interfaced. The temperature sensors in cassette should be displayed and graphed.

20.5 The actual VRV or split units are to operate under their own control but with all the key set points that would normally be on the wall mounted controller replaced and controlled by the BEMS.

20.6 The FEG to show all of the set points and control options, the temperature sensors in the cassettes and the BEMS wall mounted temperature sensor.

20.7 The actual control will vary depending on application. General areas with both heating and cooling via the cassette and with a significant dead band between heating and cooling to have different fan and louvre settings for heating and cooling.

20.8 The system to be set up to allow different temperature settings if operating with a setback period and to have a FEG switch to allow a change in the time clock from on/off to on/set back operation.

20.9 The preference is that the cassette controls in auto mode to the in-built system sensor and that the BEMS room sensor is simply displaying and recording the temperature. Where small amounts of stratification occur then this can be noted on the FEG and an offset included on the FEG or set points adjusted slightly. Hidden offsets are not to be used. If the stratification is excessive in either summer or winter conditions or problems of constant hunting or stop start operation with noticeable temperature fluctuation or user complaints then the DesOps to be changed so that the BEMS controls the on/off, heating or cooling mode, fan speed, louvre position and set points directly for both heating and cooling.

20.10 Where in-built condensate pumps are used (or where general condensate pumps are located in the cassette or pipework enclosure or adjacent in the ceiling void or space) and the cassette control interface can not inhibit cassette operation and signal a condensate pump fault alarm to the BEMS then an OK/FAULT interface and FEG should be provided direct via the condensate pump. A condensate pump fault should inhibit the operation of that cassette only.

20.11 Where high quality condensate pumps are used in special locations (IT Server rooms, certain labs, CRAC units, ceiling mounted cooling coils on ventilation systems) then an OK/FAULT interface and FEG should be provided. Whether this is to inhibit the cassette or coil will depend on the application and covered by the DesOps and depend on whether the overflowing condensate is less of an issue than equipment overheating.

20.12 Where cassettes provide cooling but heating is via another system such as radiators etc. then the cooling set point needs to have a significant offset from the heating set point with on/off control of the cassette via the BEMS. Local 2 port control valves controlled by the BEMS are required to ensure local heat emitters such as radiators or capillary controlled radiant panels are not adding heat to the space when the cooling is required.

20.13 There should be notes on the FEG confirming the agreed set up when commissioning along with any key design criteria.

21.0 Fan Coil Units – 2 & 4 Pipe Providing Cooling or Heating and Cooling

21.1 Local control units to be housed in a dedicated enclosure for each fan coil unit. Pressure transducer required across any filters. Temperature sensors to measure the return air and supply air but with actual control with reference to a wall mounted temperature sensor. Control valves to be fully modulating and either a PICV or 3 port mixing to divert from the coil.

21.2 The controls and valves need to be as per the other specification requirements; if the manufacturers inbuilt system fully complies then these can be used otherwise standalone local controls will need to be used.

21.3 The BEMS to have set point for heating with offset to give the calculated cooling set point, fan on/off control, fan speed control on the FEG. The fan speed should have a minimum and maximum setting and should modulate based on demand; typically when the valve is <60% open the fan should be at minimum and then increase to maximum as the valve increases to 100% open.

21.4 The system to be set up to allow different temperature settings if operating with a setback period and to have a FEG switch to allow a change in the time clock from on/off to on/set back operation.

21.5 The dirty filter condition and set point along with the air flow proving and set point should be on the FEG. Where the fan coil unit is serving a dedicated space there is no requirement for a separate pressure transducer to measure the duct static; the air flow proving can be based on a minimum pressure across the filter.

21.6 The FEG to show all of the set points and control options, the temperature sensors in the VRV or split and the BEMS wall mounted temperature sensor. It should also show the LPHW and ChW main flow and return temperatures on the circuit serving the fan coils as measured at either local sensors or at the main plant.

21.7 Where separate condensate pumps are used that are located outside of the fan coil unit housing then an OK/FAULT interface and FEG should be included.

21.8 Where in-built condensate pumps are used (or where general condensate pumps are located in the fan coil unit or pipework enclosure or adjacent in the ceiling void or space) and the fan coil control interface can not inhibit cooling operation and signal a condensate fault alarm to the BEMS then an OK/FAULT interface and FEG should be provided direct from the condensate pump.

21.9 Where high quality condensate pumps are used in special locations (IT Server rooms, certain labs, CRAC units, ceiling mounted cooling coils on ventilation systems) then an OK/FAULT interface and FEG should be provided. Whether this is to inhibit the fan coil unit will depend on the application and covered by the DesOps and depend on whether the overflowing condensate is less of an issue than equipment overheating.

21.10 Where fan coils provide cooling but heating is via another system such as radiators etc. then the cooling set point needs to be a fixed offset from the heating set point with on/off control of the cassette and then cooling and fan speed via the BEMS.

21.11 Where fan coils provide cooling but heating is via another system such as radiators etc. then the cooling set point needs to have a significant offset from the heating set point with on/off control of the fan coil via the BEMS. Local 2 port control valves controlled by the BEMS are required in the local heating system to ensure local heat emitters such as radiators or capillary controlled radiant panels are not adding heat to the space when the cooling is required.

21.12 There should be notes on the FEG confirming the agreed set up when commissioning along with any key design criteria.