Building Management Systems (BMS)

TECHNICAL GUIDELINES

University of British Columbia Okanagan

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Contents

1 OVERVIEW

1.1. General

A. The University of British Columbia is a large campus with numerous buildings of various ages. A significant number of these buildings are of a vintage that predates modern microprocessor based HVAC control systems and these older building control systems are continuously being upgraded. New buildings are also being constructed at the UBC Campus on an on-going basis.
To assist in the operation and maintenance of campus buildings, UBC Building Operations provide centralized monitoring and control of UBC buildings from a central location via microprocessor based DDC controls. To facilitate the centralized BMS monitoring and control standards have been applied to the selection of BMS equipment and for the application of BMS installations in buildings. The UBC BMS Design Guidelines serve to identify typical standards for the application of BMS's in UBC buildings. These Design Guidelines have also been developed to assist UBC in ensuring that UBC buildings are provided with high quality BMS installations that fully meet their requirements.

1.2. Application of these BMS Technical Guidelines

A. This document is intended to serve as a guideline for the Design of Building Management System (BMS) installations in buildings at the University of British Columbia Okanagan (UBCO). The guideline serves to generally identify the existing UBC Campus BMS infrastructure and installed components and to record BMS design requirements specific to UBCO installations. The UBCO Technical Guidelines may be used by BMS Designers for guidance in the design of UBC BMS installations but shall not be reproduced, in whole, or part, for inclusion in BMS Design Specifications, or Tender or Contract Documents. The UBCO BMS Technical Guidelines are not Design Specifications and do not include sufficient detail to be used as such. BMS Designers will be required to include additional detailed information in BMS Design Specifications to clearly identify all aspects of the BMS installation.

B. BMS Designs shall be based on sound industry standard practices. BMS Designers shall provide BMS Designs that have been specifically engineered for the application and shall exercise discretion in the application of these guidelines. All new building construction at UBC will utilize DDC BMS monitoring and control of building equipment and systems to some degree. Existing buildings are also being upgraded with retrofits to mechanical and electrical systems as well as to the building control and monitoring facilities. BMS Design Documents shall clearly identify the nature of the BMS installation work and shall include the contractual documentation and requirements where applicable.

C. All new BMS installations shall comprise equipment, data and data communications that are fully compliant with ANSI/ASHRAE Standard 135-2001 "BACnet" and Division27 Section 27 05 08 – 1.4.8.

1. Legacy equipment that are not compliant with ANSI/ASHRAE Standard 135-2001 shall NOT be used for NEW BMS installations.

2. Equipment installed on extensions of a BMS using non-BACnet legacy equipment, , shall have the capability of directly communicating to the legacy equipment in the proprietary communications protocol as well as communicating with BACnet devices. New equipment that does not have the capability to communicate in both the proprietary protocol and BACnet is placed onto a legacy system; the device shall use the BACnet communications protocol. When equipment capable of

communicating only with BACnet is placed onto an existing legacy system, a communication gateway device shall be placed on to the proprietary network. The gateway shall bridge the two disparate communication protocols and act as a translator that allows bilateral communication between the BACnet compliant devices and devices communicating using proprietary communication protocols.

1.3. List of Abbreviations

A. The following are a list of abbreviations used throughout these design guidelines and are also abbreviations used by the University of British Columbia relating to Building Management Systems.

ANSI -	American National Standards Institute
ASC -	Application Specific Controller
ASHRAE -	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM -	American Society for Testing Materials
AWG -	American Wire Gauge
B-AWS -	BACnet Advanced Operator Workstation: The B-AWS is the advanced operator's window into a BACnet system. It is primarily used to monitor the performance of a system and to modify parameters that affect the operation of a system. It may also be used for configuration activities that are beyond the scope of this standard.
B-OWS -	BACnet Operator Workstation: The B-OWS is used for monitoring and basic control of a system, but differs from a B-AWS in that it does not support configuration activities, nor does it provide advanced troubleshooting capabilities.
B-OD -	BACnet Operator Display: The B-OD is a basic operator interface with limited capabilities relative to a B-OWS. It is not intended to perform direct digital control. The B-OD profile could be used for wall-mounted LCD devices, displays affixed to BACnet devices; handheld terminals or other very simple user interfaces.
B-BC -	BACnet Building Controller: A B-BC is a general-purpose, field-programmable device capable of carrying out a variety of building automation and control tasks.
B-AAC -	BACnet Advanced Application Controller: A B-AAC is a control device with limited resources relative to a B-BC. It may be intended for specific applications and supports some degree of programmability.
B-ASC -	BACnet Application Specific Controller: A B-ASC is a controller with limited resources relative to a B-AAC. It is intended for use in a specific application and supports limited programmability.
B-SA -	BACnet Smart Actuator: A B-SA is a simple control device with limited resources; it is intended for specific applications.
B-SS -	BACnet Smart Sensor: A B-SS is a simple sensing device with very limited resources.
BMS -	Building Management and Control System
BACnet -	Building Automation and Controls Network - ANSI/ASHRAE Standard 135-2012

BTL -	BACnet Testing Laboratory: A recognized, independent third party laboratory certified to test product for compliance to BACnet standards.
BTL Mark -	A seal affixed to product certifying that it has been tested by a recognized BACnet Testing Laboratory and found to conform to BACnet standards.
CBMS -	Campus Building Management System
CCF -	BMS Central Computer Facility
CCP -	Communications Control Panel
CPU -	Central Processing Unit
DAU	Data Archival Unit. A device that sits on the Automation Network Level and automatically collects data to be sent up to the central data archive server that resides on the Management Level network and is located in the MACC.
DCP -	Distributed Control Panel
DDC -	Direct Digital Control
DELTA	Delta Controls Inc.
ESC	ESC Automation Inc. is the installing contractor and local representative for DELTA Controls.
FAS -	Fire Detection, Alarm and Communication System
FTS -	Field Termination Schedule
H/O/A -	Hand/Off/Auto Motor Control Switch/Circuit
HDAS	Historical Data Archiving Server
HVAC -	Heating, Ventilating and Air Conditioning
IEEE -	Institute of Electrical and Electronics Engineers
I/O	Input/Output
JCI	Johnson Controls, Inc.
LAN -	Local Area Network
LCD -	Liquid Crystal Display
LED -	Light Emitting Diode
LON -	Local Operating Network
LonTalk -	The open control networking protocol developed by Echelon Corporation
LONWORKS	Echelon's family of hardware and software products
MACC-	BMS Master Alarm and Control Centre
NDS -	Network Data Server
NEC -	National Electrical Code
NEMA -	National Electrical Manufacturers Association
OIW -	Operator Interface Workstation
PC	Personal Computer
PICS	Protocol implementation conformance statement: All devices conforming to the BACnet protocol shall have a documented statement (PICS) that identifies all of the portions of BACnet that are implemented in the device.
POT -	Portable Operator Workstation
PIM	Process Interface Module
RAM -	Random Access Memory
RFI	Radio Frequency Interference

RH	Relative Humidity
ROW -	Remote Operator Workstation
RTD -	Resistance Temperature Device
SBT -	Siemens Building Technologies Ltd.
SVGA -	Super Video Graphics Adapter
UBC -	University of British Columbia
UC	Unitary Controller
cUL	Underwriters Laboratory Canada
UPS -	Uninterruptible Power Supply Unit
VDU -	Video Display Unit

2 BMS INSTALLATION GUIDELINES

2.1. General BMS Installation Requirements

A. This section of the UBC Design Guidelines identifies minimum requirements for BMS field installations. BMS designs shall include these requirements and BMS designers shall ensure that design specifications include these requirements.

B. *BMS vendors for new construction shall be one of the following:*

1. *Siemens*
   a. *Utilize existing Desigo CC software running on a virtual server*
2. *Delta*
   a. *Utilize existing enteliWEB software running on a virtual server*

C. *All DDC connected devices shall be provided in SI units from the factory. Local conversions are not acceptable. This applied to all devices connected to the BMS system as well. No imperial units are acceptable.*

D. All building controls shall be by the base building contractor (existing buildings) or one of the three approved controls vendors (new construction, or if the competing controls contractor wants to replace all of the existing building controls with their system).

E. Integrations that provide control that is not completely controlled by the base building controls contractor is not acceptable

1. The following items are not acceptable:
   a. Air handling unit package controls
   b. VAV box packaged controls
   c. Damper packaged controls
   d. Fan coil packaged controls
   e. HRV packaged controls
   f. *High plume laboratory exhaust systems and their associated bypass dampers.*

F. Acceptable third party controls

1. Devices that serve as a safety device that would have special requirements that cannot normally be executed by a controls contractor.
2. Devices that meet these requirements:
   a. Variable speed drives.
   b. Kitchen ecology units
   c. Chiller controllers for modular chillers
   d. Boiler controllers for modular boilers
   e. *VRF systems*
3. These devices still have the requirement to integrate via BACnet.

G. Exceptions are acceptable. But must be approved by UBC - BMS.

H. All BACnet equipment and software supplied for the projects shall be supported by manufacturer supplied PICS (Protocol Implementation Conformance Statement) certifying that the device complies with the specified BACnet requirements.
1. All products have a BTL Mark certifying that the product was independently tested by a third party testing facility and complied with BACnet conformance requirements.

I. Design Specifications for BMS Installations shall provide detailed specifications for the all components of the BMS including equipment, field devices, wire/cable, conduit, pneumatic tubing, mounts, terminations, etc.

J. The BMS Designer shall fully coordinate BMS design requirements with the other project design team parties (where applicable). The BMS Designer shall coordinate field panel mounting locations, intended DCP/ASC locations, power supply requirements, communications outlet requirements, etc.

K. All new BMS Installations shall be integrated into the base building CBMS.

L. The following are general installation guidelines for BMS installations:

1. All equipment and materials furnished shall be new.
2. Wherever possible all similar components (e.g. temperature sensors, differential pressure transducers, current transformer/relay combinations, signal transmitters, etc.) in a BMS installation shall be by the same manufacturer.
3. Components shall be provided which are suitable for the intended application. Components shall be capable of maintained operation in the applicable environmental conditions and operation in contact with the controlled/monitored medium.
4. With the exception of field mounted instrumentation and devices, all BMS components shall be installed in field panels. Panels and enclosures shall meet, at minimum, the following requirements:
   a. Painted steel panels with hinged locking door. All panels shall be keyed to the *controls vendors'* standard key*, or provided with non-keyed twist locks.*
   b. Ventilated to prevent excessive heat build-up, where required.
   c. Cable within enclosures shall be installed in cable *ducts* with snap on covers.
   d. Internal components shall be installed to allow easy access for diagnostics, maintenance, removal or replacement.
   e. Panel or enclosure shall be suitable rated for the environment for which it is to be installed.
   f. Exterior enclosures shall be, at minimum, NEMA 1 for indoor applications and NEMA 3R for outdoor applications.
5. Panels and enclosures shall only be located within mechanical rooms or at approved locations. Panel locations shall be coordinated during design by the BMS Consultant and shall be identified on project design drawings. For new construction projects the BMS panel locations shall be identified in the project mechanical design drawings, and coordinated on site. For retrofit applications the BMS panel locations shall be identified on building floor plan drawings and in the graphics package to be included in the project BMS Specifications/Contract Documents.
6. All components of the BMS shall be Identification tagged. Identification tags shall be *resistant to mechanical damage and* securely fastened to the device. Identification tags shall be provided for, at minimum, the following;
   a. Sensors.
   b. Transmitters.
   c. BMS controlled valve and damper actuators.
   d. End-Devices (other).
   e. Field panels.
7. All BMS wire and cable and pneumatic control tubing shall be identification tagged.

Wire/cable shall be identification tagged at every termination location. Wire/cable and tubing terminating at DCP's and ASC's shall be tagged with the point name (full point name, using the UBC standard {buildingnumber.system.device.point}. At any splices or terminal strips between the field device and DCP/ASC, the wiring shall be tagged on both sides of the termination point the same as for a field device termination.

8. 120 VAC power supply sources shall be provided to all BMS field panel and DCP mounting locations. As built documentation shall detail power supply circuit source panels and termination locations.
9. DDC panels that require guaranteed up time, shall be connected to the building emergency power system, or the building UPS system. DDC provided UPS devices are not acceptable, except by exception.
    a. For Okanagan – All DDC panels that require guaranteed up time shall be provided with dedicated UPS device. UPS Shall be online/double conversion type with hot-swappable batteries such as Eaton 9SX1500 or equivalent.
    b. All BMS UPS shall include hard-wired general fault alarm.
10. All installations shall be provided to readily allow access for maintenance.

M. The BMS specifications shall identify requirements for all work to be provided by the BMS Contractor including all boring, saw cutting, fire stopping, sleeves, equipment mounting and supporting, etc.

2.2. BMS Electrical Installation Requirements

A. All BMS wiring, conduit, junction boxes, pull boxes, cable tray, etc. shall be provided by the BMS Subcontractor as required for a complete installation. The BMS Contractor shall provide all required access panels, coring, saw cutting, fire stopping, mounting, etc. as defined by the specific job contract documents.

B. The BMS Contractor shall coordinate installation of conduit with building structure and other trades. Conduit installation above accessible ceilings shall be such that there will be no interference with the installation of lighting fixtures, fire protection, air outlets or other devices. Color code *or place identifying stickers at* all conduit and fittings with a unique color at every junction box and at least every 3 m along the conduit. BMS conduit shall be identified by a blue colour code.

C. BMS wire/cable shall not share conduit with other building wiring. Low voltage cable shall not be installed in conduit with line voltage or higher voltage carrying cable.

D. The following are minimum requirements related to BMS electrical installations:

1. With the specific exception identified within this document, all BMS wire and cable shall be installed in conduit.
2. In new construction projects exposed conduit installations are not permitted in normally occupied building spaces. In retro-fit applications exposed conduit shall only be allowed in specific applications as approved by the BMS Consultant and UBC.

E. Conduit:

1. Conduit shall be run in all areas *exposed to mechanical damage.*
2. Conduit must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Conduit sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.
3. Secure conduit with conduit clamps fastened to the structure and spaced

according to code requirements. Conduit and pull boxes shall not be hung on flexible duct strap or tie rods. Conduit, junction boxes, pull boxes, and control panels shall not be run on or attached to ductwork.

4. Conduit fill:
   a. Shall meet the requirements of the Electrical Specifications for line voltage or AC power runs.
5. Junction or pull boxes shall be installed:
   a. Every 25 meters for 12mm conduit runs,
   b. Every 30 meters for conduit greater than 12mm,
   c. After the equivalent of four (4) 90° bends have been made. Every offset counts as ½ of a 90°, and each saddle counts as one 90° bend,
   d. All junction boxes shall be installed in accessible locations.
6. Use of flexible or BX (or equivalent) shall be limited to a maximum length of one (1) meter, and shall be supported on each end*, which connects to an end device.*
7. Exposed conduit ends shall have bushings installed to protect wiring running through the end of the conduit.
8. Flexible conduit shall have anti-short inters installed at each end to protect the wire or cable running through the end,
9. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
10. Wire/cable for space temperature sensors, VAV terminal unit damper actuator, zone coil control valve actuator, VAV terminal unit ASC automation LAN and (where applicable) 24VAC power supply distribution wiring may be installed in ceiling spaces without conduit where code permits.
    a. Wire/cable installed in ceiling spaces without conduit shall be suitably rated and labelled.
    b. Wire/cable shall be securely supported and installed in a neat and workmanlike manner following building lines.
    c. Sleeves shall be provided for all wire/cable that penetrates wall partitions, concrete slabs, or rated partitions.

F. BMS low voltage monitoring and control wiring shall meet the following minimum requirements:

1. Minimum #22 AWG stranded copper conductors (larger gauge wire/cable shall be provided where required by BMS equipment and where applications warrant (e.g. long runs, etc.).
2. All BMS input/output point wire/cable and communication cable shall be shielded.
   a. Non-shielded cables may be approved for BMS input and output field point wiring following certification from the BMS manufacturer that non-shielded cables will function satisfactorily for the life of the building and that the use of non-shielded cables will not negatively affect other building systems/cabling.
   b. The manufacturers certification shall guarantee to UBC that should it be determined that BMS system performance is negatively affected or another building system or equipment is negatively affected due to the non-shielded cable, the BMS manufacturer shall replace the cable at no cost to UBC.
3. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.
4. Free air cabling installed in non-combustible rated buildings shall be fire rated cable with a minimum rating of FT-6.
5. Wiring located in combustible rated buildings above T-bar ceiling shall be run in free air using fire rated cable with a minimum rating of *FT-6*.
   a. Note: all free air cabling used in combustible rated buildings to interface to

security or fire alarm systems shall be FT-6 rated.

b. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

6. Cables shall follow building lines and be installed in bundles resting in a cabling support system (J-hooks, Bridal Rings, eye wraps can be used.) Where possible have wires installed to ceiling or highest possible elevation.
7. Cable supports shall be attached to the wall or ceiling of the area they are running through. Cable supports **shall not be attached** to:
   a. Electrical raceways,
   b. Duct work,
   c. Ceiling suspension systems,
   d. Piping,
   e. Wilson joists.
8. Cabling bundles inside controls enclosures shall be held in the cable support system using Velcro straps, “zap straps” are not acceptable.
9. Cable straps (Zap straps) are acceptable outside of control enclosures.

G. Data Communication Cabling shall meet the following minimum requirements:

1. Unless otherwise specifically called for in the specifications, uniformity of manufacture to be maintained throughout the building for any particular item or type of equipment.
2. All data cabling shall use stranded conductors. Solid core conductors are not accepted.
3. Data cabling shall be run *as per the vendors best practice guidelines.*
4. Communication runs be one continuous run from end to end without splices or connections,
5. All multi-conductor cabling shall be colour coded.
6. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standar*d 135, and the appropriate vendor standards. This includes but is not limite*d to:
   a. The maximum length of an MS/TP segment is 900 meters (with AWG 22 cable. The use of greater distances and/or different wire gauges shall comply with the electrical

      Specifications of EIA-485.
   b. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters. Exceptions can be approved by the UBC-BMS group.
   c. An MS/TP EIA-485 network shall have no T connections.

H. BACnet Ethernet communications cabling shall meet the following minimum requirements:

1. Data cable shall Category 5e Ethernet cable minimum, category 6 is preferred.
2. The maximum cable length for each run shall be limited to 90 meters.
3. All Category 5 cables must be Power Sum accepted and recognized by the manufacturer.
4. Cable Skew must be specified as 20Ns or less per 100 meters.
5. Cables must display the manufacturer’s stamp stating that the cable is included in the latest UL verified publication for Category *5e* standards.
6. All cables must be included in the System / Applications Certification Warranty.
7. All cabling installed inaccessible areas, (above drywall ceilings, and crawl spaces), must be installed in conduit or cable tray. Conduit fill must not exceed 40%.
8. Ethernet Cable Testing:
   a. The Controls Contractor is to use a Level III tester that is capable of testing

the specified cable to the performance level(s) indicated in this document. The tester is to use the latest version of firmware and software to test the unshielded twisted pair (UTP) cabling system.

b. The nominal velocity of propagation (NVP) must be set specific to each cable manufacturer before testing. Portable tester is to be calibrated on a minimum annual basis.

c. The Consultant before the commencement of all field-testing may perform a visual inspection. The installation will be validated for compliance with the Industry Standards with particular attention given to the following criteria:
   I. Cable jacket removal and connector termination.
   II. Routing and pathway supports.
   III. Cable bend radius and cable tie slack.
   IV. Neatness, clamping, and harnessing of cabling and wiring.
   V. Wire and cable identification and labeling.
   VI. Nameplates, identification, plates, and markings.

d. Provide two copies of testing and commissioning documentation for all items and their related components to the Project Manager and Owner's Designated Representative before the designation of substantial completion for the project. Include maintenance manuals and operating instructions for Customer's staff use. Substantial completion will not be granted until all documentation has been submitted and accepted by the Consultant.

e. The permanent link performance of the installed cabling Data system must comply with EIA / TIA 568B-1 specifications for testing Category 5e systems. All horizontal channel testing shall be performed end to end for each port, (Dual NEXT). No conditional passes will be accepted.

f. Testing of all 4 pairs of the horizontal cable (as specified in this document) is to include but not be limited to the following:
   I. Wire Map including; end to end continuity, open and shorts, pair polarity
   II. Cable length
   III. Attenuation
   IV. NEXT/FEXT
   V. ACR
   VI. Return Loss
   VII. ELFEXT, PSELFEXT
   VIII. Propagation Delay, Delay skew
   IX. PSNEXT, PSACR.

g. All of the above parameters must be recorded and included in the test results.

h. Correct all cable faults. Splicing of any cables will not be permitted, for any reason, unless prior authorization is received in writing from the Consultant.

i. The Controls Contractor shall supply the Consultant with test results for approval and system acceptance. An additional copy of the test results is to be included for the maintenance manuals.

I. Wiring runs shall be continuous runs without splices.

J. All BMS equipment and components shall be grounded to building ground facilities.

K. BMS shall only be capable of controlling electric motors when the associated hand/off/auto (HOA) motor control switches are in the "auto" position. BMS control shall be wired into the auto circuit of the hand/off/auto motor control circuit only. Where hand/off/auto switches do

not exist they shall be provided by the *electrical* contractor.

L. Life safety and equipment protection interlocks shall be wired to override equipment whenever it is in operation.

M. Existing interlocks and override control facilities should typically not be removed or overridden by the application of new BMS control facilities without the specific instruction of the BMS Design Consultant and the approval of UBC Building Operations.

2.3. BMS Communication Provisions

A. The following minimum requirements shall be provided *by UBC IT group / Construction team*:

1. *One female data connection will be provided for every DDC panel. This location to be coordinated with the construction team/UBC-CI/UBC-BMS.*
2. *For ethernet connected terminal equipment, quantity and locations to be coordinated with the construction team/UBC-CI/UBC-BMS.Maximum number of devices connected per data connection shall not exceed 6,* except by exception.

2.4. BMS Pneumatic Control Installation Requirements

A. *Pneumatic are only approved by exception, as approved by UBC-BMS in buildings with existing pneumatic systems. Pneumatic specifications are available upon request.*

2.5. BMS Installation Training Requirements

A. The *project* BMS Specifications shall specify requirements for CBMS/BMS training to be provided as part of the work of all CBMS/BMS projects. CBMS/BMS Contractor shall submit an outline of the training courses to be given.

B. Training sessions shall include classroom type instruction and "hands on" instruction and shall be given by the BMS Subcontractor on site using the completed installations. Arrange for additional meeting room space with the Owner.

C. Provide training tailored to the various Owner operations personnel requirements. Duration and number of training sessions to be determined by the BMS Consultant and shall be specified to accommodate the installation requirements.

D. The BMS Contractor shall provide initial basic monitoring and control training to the Owners personnel to provide them with sufficient knowledge of the BMS installations such that they can use the BMS for the day-by-day monitoring and control of the BMS.

E. The advanced BMS training shall, at minimum, cover the following topics:

1. *Site review (equipment and device locations)*
2. *Sequence of operations and programming review.*
3. *Graphic package review.*
4. *System interaction review.*
5. *Sharing of special case situations that have occurred during construction.*

F. Training sessions shall be designed on the basis of experience and knowledge of the attendees scheduled to participate and shall differentiate between the requirements of supervisory, operations and maintenance personnel.

G. The BMS Subcontractor may provide computer based, self-directed training accomplish the portions of the UBC training requirements. Provide onsite training for details specific to the particular BMS installation project (i.e. device locations, sequences of operation, safety devices, life safety system interlocks, maintenance procedures, etc.). Provide site training for any new products, equipment, devices, and software.

2.6. BMS Documentation Requirements

A. The BMS Specifications shall specify requirements for CBMS and BMS documentation to be provided as part of the work of all CBMS/BMS projects.

B. *A Graphics package shall match the vendor specific requirements for each system.*

1. *Delta:*
   a. *Graphics shall be HTML5, using the standard that has been developed in conjunction with Kimco.*
   b. *Old graphics are acceptable by exception, on existing buildings only*
2. *Siemens Building Technology:*
   a. *Graphics shall be Desigo graphics, using the standard developed by UBC-BMS.*

C. Shop drawings shall be generated *in a digital format.* Drawings shall include diagrams, mounting instructions, installation procedures, equipment details and software descriptions for all aspects of the system to be installed. All shop drawings shall be indexed. At minimum, the shop drawings shall include:

1. BMS topology/network architecture schematic(s).
2. Installation drawings and schedules.
3. Protocol Implementation Conformance Statements (PICS),
4. CCP, DCP, UC and other panel layouts, including floor plan location and interconnection drawings.
5. Field instrumentation locations on floor plan drawings.
6. Schematic of systems indicating instrumentation locations.
7. Installation details.
8. Schedule of cabling including details of proposed cable types.
9. *Wiring details drawings*

D. Equipment submittals shall include design, performance and installation details for all aspects of the system to be installed. Equipment submittals shall be in in a digital format and shall be indexed. At minimum, the equipment documentation submittals shall include:

1. Equipment technical data sheets with mounting and installation details.
2. The documentation shall include comprehensive and complete details of the Automation Level data communications, data objects, and devices including address, associated controller type, etc. as required and for the interface to the CBMS. Provide Protocol Implementation Statements (PICS) for all devices.
3. Details of networks/communications equipment, cabling and protocols proposed.
4. Software specifications and descriptions including operating sequences.
5. Field sensor and instrumentation specification sheets.

6. Damper and actuator specification sheets.
7. Valves and valve actuator specification sheets.

E. Provide record documentation in manuals as indicated below *(digital copies are preferred)*:

1. Specifications, maintenance requirements and installation requirements for all hardware components.
2. *As build package of submission package*
3. Field Instrumentation and End Device Hardware Manuals
4. Software Documentation Manuals.
5. Maintenance Manuals.
6. Control Drawings.
7. Other supporting documentation.
8. Details for IP connected equipment including the following as a minimum requirement. See Appendix B for a template for recording this information.
   a. Equipment description
   b. IP address
   c. MAC Address
   d. IP port number (CCT #)
   e. Bacnet Instance Number

F. Manuals shall be updated whenever the Subcontractor makes changes to the Work.

G. Provide one (1) complete set of all record documentation in printed hardcopy and one (1) complete set of all record documentation in .pdf electronic computer data file format.

H. All BMS and CBMS Record Documentation shall be provided in electronic .pdf file format.

I. For projects completed within an existing building, record drawings for the entire building shall be updated to include the project changes.

2.7. BMS Installation Commissioning and Testing

A. BMS specifications shall clearly specify the requirements for Contractor testing and commissioning of the BMS including test documentation and requirements for testing and demonstration with other project commissioning personnel and the BMS design consultant.

B. All commissioning shall be completed using the graphics generated for the user interface, and the graphics shall be verified at the same time that point end-to-end checks and programmed sequences of operation verifications are completed.

1. Hardware and graphics commissioning shall take place simultaneously.
2. Should the initial end-to-end checks be completed without the use of the graphics, the end-to-end checks must be completed again to confirm the point layout indicated on the graphics is consistent with the point locations in the field.

C. The BMS Subcontractor shall conduct full end-to-end testing and commissioning of the BMS installations and the overall monitoring and control of the building systems. , BMS Contractor testing shall include the monitoring and supervisory control and data communications with the associated campus NDS.

D. *The BMS Subcontractor shall work with the UBC BMS Group to ensure all controllers are visible on the network, and verify BMS integration.*

E. The BMS Contractor shall work with the UBC-BMS group to bring the building network online to the UBC-UTILNET and the associated NDS.

F. Point to point checks shall verify (at minimum) the following:

1. Correct location of the field device for the application.
2. Correct installation of the control device/interface with reference to the manufacturer's literature and check that sufficient access has been provided for maintenance.
3. That the control device has the correct range for the application, that the range is correctly entered in the controller and is correctly engineered on the operator's terminal.
4. Correct operation of the controls device/interface, including any associated alarm and alarm text.
5. Correct installation of each valve and damper actuator, and ensure that each valve and damper actuator is stroked correctly when checked against the BMS output.
6. Calibration of the control device.
7. Labels provided on the control devices and mechanical equipment is correct.

G. Systems testing shall commence once all component testing has been successfully undertaken and approved by the Consultant.

H. The *Consultant's verification tests shall be performed by the BMS Subcontractor and shall be witnessed by the Consultant or Commissioning Agent who shall complete the Consultant's portion of the system performance verification test sheets as each test is successfully undertaken. The BMS Subcontractor shall remedy any deficiencies that are observed during the system performance verification tests and shall be re-tested as required to demonstrate satisfactory performance and compliance with the specifications*.

I. Integrated BMS/CBMS joint systems tests shall be undertaken to demonstrate that the interaction between the individual building BMS and the CBMS meets the UBC requirements. The BMS Subcontractor shall participate in joint verification of the integrated systems and cooperate with the Owner in the demonstration of the integrated systems.

J. The BMS Specifications shall specify the requirements for the BMS/CBMS integration joint systems verification. The BMS/CBMS Integrated System Verification shall include the following minimum requirements:

1. Test all BMS monitored and controlled field devices, BMS data points and all BMS input and output points. CBMS monitored data point values shall be verified against actual field device position/state and compared to BMS values to ensure both BMS and CBMS values are the same.
2. CBMS override control of all BMS output points and control data points shall be verified.
3. BMS network and controller device status and data communications status are accurately monitored at the CMBS. Alarms for failed controllers and failed data communications are annunciated.
4. BMS data values displayed on dynamic system graphics or in tabular data format at the CBMS are functional and accurate.
5. CBMS operator control of BMS control output points and control data points are functional via the dynamic graphic interface.
6. CBMS facilities for operator adjustment of alarm definition parameters and thresholds, set point adjustment, control parameter adjustments, point trend

initiation and modification to trends, etc. are fully functional.

7. The CBMS performance requirements for the monitoring and control of BMS data and field devices meet the UBC requirements.
8. BMS device addressing and identification definitions are compatible and identical and the addressing scheme meets with UBC requirements.
9. All BACnet controllers addressing shall conform to the UBC schedule for BACnet device addressing.
10. Point naming used is compatible and conformal with the UBC requirements.

K. All test documentation shall be maintained in electronic format.

3 BMS DESIGN GUIDELINES

3.1. General BMS Design Requirements

A. BMS installations at UBC buildings shall be turnkey installations operating fully standalone.

B. All BMS shall conform to the most recent revision of the ANSI/ASHRAE Standard 135 including all issued addenda, at minimum, at the Management data communication network level as defined within these guidelines. All BMS devices shall implement the functionality detailed in the BACnet Standard "Device Profiles". The BMS shall also be native BACnet compliant at the Automation data communication network level.

C. The CBMS shall be compliant with the requirements defined for a BACnet Operator Workstation Device (B-OWS). The CBMS shall provide centralized operator interface for monitoring and supervisory control of the individual building BMS.

1. Each BMS manufacturer has a virtualized CBMS installed.
    a. New and renovated BMS installations shall interface to the CBMS supplied by the *UBC-BS group with software provided by UBC from the associated manufacture*:
        I. SBT BMS will interface with the *Desigo CC* CBMS,
        II. Delta BMS will interface with the *Enteliweb* CMBS.

D. The BMS Specifications for each building BMS project shall specify the requirement for the BMS Contractor/Manufacturer to provide all hardware and software required for the CBMS to communicate with the BMS via BACnet IP on the UBC campus WAN. Facilities to be provided shall include any manufacturer specific software tools required for programming, point mapping, configuration, etc. of building BMS data points.

E. UBC building BMS installations shall be specified to include all project design, documentation, training, installation work, software, database and logic programming, WAN interconnection, testing, commissioning, warranty, project management and trade coordination work as required for a fully functional, standalone, turnkey BMS. The individual building BMS installation

Contractor work shall include coordination and documentation work for the integration of the BMS into the CBMS via BACnet data interface by other contract. Installations shall in no way negatively affect existing BMS installations and existing campus BMS performance.

F. BMS installations shall be provided which incorporate BMS equipment and network facilities in compliance with the requirements identified in these guidelines. The BMS designer shall specify detailed BMS equipment requirements and BMS network architecture requirements in the BMS Design Specifications. BMS equipment and data communication network specifications shall incorporate good BMS engineering, design, and application practices and shall incorporate the UBC BMS Design Guideline requirements.

G. BMS online editing is necessary for all controllers that serve critical equipment (to be determined by project team) which cannot be shut down without a maintenance shutdown notice.

H. BMS installations in UBC buildings shall incorporate the following minimum requirements:

1. Management and Automation Level communication LAN's shall be provided to ensure the following:

2. The failure of a DCP shall not affect the operation of other operating DCP. UC's supervised by the failed DCP shall continue to function and shall control associated equipment according to specified failure routines. Where information in the failed DCP is used by other DCP's, UC's, buildings, routines, etc. the non-availability of the information shall be alarmed and alternate control strategies shall be automatically initiated.
3. The failure of an UC shall not affect the operation of other operating UC or DCP.
4. All BMS monitored and controlled points associated with an individual HVAC System or equipment shall be terminated in the same UC or DCP. It is not acceptable for BMS monitored and controlled points associated with an individual system to be terminated at separate distributed DCP's or UC's. All required logic programming and point database facilities associated with an individual building system shall reside in the same UC or DCP to which the system input/output points are terminated. It is not acceptable for logic programming and database facilities required for BMS monitoring and control of a building system to reside in a DCP or UC other than to which the system input/output points are terminated in.
5. UC's controlling space terminal units (e.g. VAV terminal units, fan powered terminal units, etc.) shall reside on the same automation LAN as the UC that is controlling the associated air handling unit. If an AHU is controlled directly by a DCP, the UC's controlling space terminal units shall be supervised by that DCP.

3.2. BMS Subcontractor and System Qualifications

A. Products shall be provided by one of the approved control vendors for new buildings. For existing buildings, products shall be the same as the base building vendor.

B. BMS facilities to be provided for UBC building installations shall be fully compatible with the existing installed central monitoring and control facilities, network communications facilities, and with other UBC building BMS installations.

C. All BMS DCP's, UC's, OIW's where applicable, and other BMS Manufacturer specific equipment within a building shall be manufactured by the same manufacturer. All HVAC and building services monitoring and control shall be provided by BMS facilities from one of the approved UBC BMS manufacturers. In applications where HVAC system controls within an existing building are being retrofitted and BMS facilities of any of the approved BMS manufacturers exist within the building, BMS facilities shall be provided by the manufacturer of the BMS equipment already installed. The retrofitted BMS installation shall be provided to interconnect the new renovation work into the existing building and campus BMS facilities.

D. BMS DDC controllers shall be products manufactured by a company that is an active Corporate Member of the BACnet Manufacturers Association (BMA).

E. All BMS products proposed for installation on a UBC project shall have been previously demonstrated to UBC Building Operations satisfaction and approved by UBC Building Operations prior to being listed as an approved bidder. Any BMS product/equipment for which there is not a significant existing installation on campus of products from the same manufacturer that is successfully integrated with the CBMS shall be fully demonstrated to UBC's satisfaction and approved by UBC Building Operations prior to being considered as an approved product.

3.3. BMS Network Architecture and Communications Requirements

A. The CBMS and the individual building BMS systems shall be based on multiple tier/level data communication networks utilizing different network communications technologies. The CBMS and the individual building BMS system architecture shall comprise of three layers

as defined within these documents.

B. BMS design specifications shall detail the data communications network facilities to be provided and the contracting party responsible for providing the work.

C. The CBMS/BMS architecture shall comprise the following network layers:

1. Management Level (by CBMS and BMS Contracts):
   a. A Wide Area Network (the UBC Campus WAN) shall provide a means of interoperable communication between the CBMS and the individual building BMS using BACnet/IP. This WAN is hereafter referred to as the Management Level Network. The Management Level Network shall provide a means by which the building systems throughout the UBC facilities can exchange data in the form of BACnet data objects. The Management Level Network shall be BACnet/IP over Ethernet and shall be such that an operator with the required access level shall be able to undertake monitoring and control functions for any of the integrated BMS buildings.
   b. It shall be the responsibility of each BMS building contractor, to ensure that all BMS system data is available at the Management Level Network. The intent is that the CBMS shall be able to automatically read this data from the network using the BACnet automatic “find new objects” features. Each BMS building system contractor shall provide comprehensive and complete documentation regarding the installed BACnet devices, device address, controller type, databases and other pertinent information to the Owner and to the CBMS contractor. BMS Specifications shall specify the inform
   c. Each BMS system shall have a dedicated NDS installed at the UBC MACC. The NDS shall be dedicated to campus building BMS’s of the same manufacturer product. The NDS shall have terminal service capabilities with “Thin Client” operator interface or shall employ “web services” technology such as Microsoft .Net technology with web browser based operator interface. The NDS shall communicate with the individual building BMS’s over the BMS Management Level via BACnet/IP. The NDS shall have manufacturer specific application software for operator interface. The NDS shall be configured for archiving and data storage of all associated BMS controllers and devices and for manufacturer specific controller programming, trouble shooting, data entry, configuration software tools, etc. It is not intended that the NDS be configured as the central operator monitoring and control workstation.
   d. The CBMS shall be in conformance with the requirements and functionality detailed in ANSI/ASHRAE Standard 135 (BACnet) for a BACnet Operator Workstation (B-AWS). The CBMS shall have terminal service capabilities with “Thin Client” operator interface. The CBMS shall communicate with the individual building BMS’s over the BMS Management Level via BACnet/IP. CBMS applications software shall run on the existing SBT Apogee NDS server computer installed at the UBC MACC. The CBMS workstations, including the Portable Operator Workstations (POT), shall be Thin Clients operating through a Virtual Private Network (VPN). It shall be possible to add access from a remote location by modem and/or via the Web.
   e. The Management Level Network communications, without exception, shall be BACnet/IP. It is intended that there be a single point of interface between a building BMS and the Management Level Network (UBC WAN). If multiple

      CCP are required in a building due to Automation Level node quantities or limitations of CCP capabilities, the BMS Contractor shall add the additional CCP as an extension of the Management Level Network within the *building*. The BMS Contractor shall provide Management Level network facilities within individual buildings.

f. The demarcation point between the CBMS and the building BMS shall be the BMS CCP connection to the WAN data outlet within the building. The BMS Contactor shall make the final terminations with supervision from UBC.

2. Automation Level (by the BMS Contract):
   a. The Communication Control Panels (CCP) shall be part of the BMS. CCP shall be software programmable and shall incorporate BACnet/IP to BACnet/MS/TP routers between the Management Level Network and the BACnet controllers on the Automation Level Network.
   b. The Automation Level shall primarily include the DDC controllers that interface with the field sensors and final control elements. It is anticipated that there will be two types of DDC controller within the CBMS architecture:
      I. Distributed Control panels (DCP).
      II. Unitary Controllers (UC).
   c. DCP controllers shall be fully programmable controllers and shall have an I/O capability to handle major types of equipment such as air handling units, roof top units, chiller plants, heating plants, etc. The DCP shall be BACnet Building Controller (B-BC) type controllers and shall be interfaced with the Management Level Network via the CCP. DCP may incorporate CCP functionality and reside at the Management network level.
   d. UC shall be application specific or fully programmable controllers and shall be suitable for the monitoring and control of specific types of smaller equipment such as VAV terminal units and Fan Coil Units. UC shall be BACnet Advanced Application Controller (B-AAC) and/or BACnet Application Specific Controller (B- ASC) type controllers at the Automation Level. These UC shall operate on the same network as the BACnet DCP.
   e. All controllers shall be BACnet compliant. Where testing protocols and certification requirements are developed for standardized BACnet device types, devices must be tested and certified compliant by the BACnet Testing Laboratory (BTL). For BMS standardized devices where testing protocols and certification requirements are not yet finalized, the BMS product manufacturer must demonstrate committed efforts to comply with BACnet Standard requirements for the device and an ongoing commitment to undertake the future testing and certification process. All BMS controllers shall be tested and certified within a reasonable period of time of the testing and certification process being available.
   f. The BMS Automation Level Networks shall be BACnet MS/TP protocol *or BACnet IP*. No other protocols or network architecture shall be used, including BACnet Ethernet protocol. Where BACnet IP protocol is implemented, UDP port shall be separated by vendor as follows:
      a. Siemens – port 47808
      b. Delta - port 47809
   g. Where interface to a third party controller is not BACnet compatible, the interface shall be accomplished through a point-for-point, hardwired interface.

3. Field Level (by BMS Contract):

   The Field Level shall include the instrumentation interfaced to the Automation Level DDC controllers such as the temperature, humidity, level, pressure sensors and switches. It shall also include the final control elements such as the valve and damper actuators and the control relays.

4 BMS EQUIPMENT

Refer to section 4 of Vancouver Building Management Systems (BMS) Design Guidelines (section 25 05 00) for equipment requirements, with exceptions as indicated in this section.

4.1. Management Level Network

A. Extension of the Management Level Network shall meet, at minimum, the following requirements:

1. Ethernet TCP/IP network. The CCP, OIW, NDS, POT and CBMS shall communicate at 100Mbs or higher communication rates.
2. All data communications shall be BACnet/IP
3. Cabling shall be Category 5e or higher quality and shall be tested and certified for 1 Gbps data transfer rate.
4. Network equipment, configurations, and data communications shall be fully compatible with the UBC Campus WAN.

B. OPERATOR INTERFACE WORKSTATION (OIW)
1. Not used on campus.

C. WEB SERVER OPERATOR INTERFACE (WOI)
1. Servers are determined by the vendors and are approved by the Energy Team. All servers are in place and shall be connected to by the end users via thin or fat clients.

4.2. BMS Automation Level Network

A. BMS Automation Level LAN shall meet, at minimum, the following requirements:

1. BACnet IP and/or BACnet MS/TP protocol implemented via EIA-485.
   a. Data transfer rate and data throughput as required to meet the alarm annunciation requirements.
2. BACnet IP protocol implemented via Ethernet.
   a. Data transfer rate and data throughput as required to meet the alarm annunciation requirements.

B. The failure of any node on the Automation Level LAN shall in no way affect the operation of the BMS except to inhibit monitoring and control functions at the OIW for that node or any devices served by the failed node.

C. The failure of any node shall not inhibit the communication between remaining nodes.

D. For BMS Field Device and Instrumentation requirements, see section 4.6 of the Vancouver BMS Design Guidelines.

4.3. Electrical Meters

A. *This section details the minimum requirements for the electrical primary and secondary meters. Electrical secondary meters shall be provided, installed and commissioned by the BMS trade.*

B. *The BMS vendor shall provide an approved electrical meter assembly as required for the building design. The electrical meters shall be integrated into the building BMS system.*

C. *All electrical sub meters shall meet all required local and national certification requirements.*

D. *All current transducers shall be provided by the electrical trade, and shall be Rogowski Coil type.*
E. *BACnet network requirements:*
   1. *BACnet IP requirements*
      a. *BACnet IP is the only acceptable communication protocol.*
      b. *BACnet gateways are not acceptable.*
      c. *UDP port configuration is required (47800 – 47820)*
      d. *Devices must comply will all other BMS requirements.*
      e. *Sub point naming must be available, and adjustable. Default names are not acceptable.*
   2. *Primary building meter shall be ANSI X12.20-2015 class 0.2 revenue grade or better.*
   3. *Secondary building meter shall be ANSI X12.20-2015 class 0.5 revenue grade or better.*
F. *All electrical meters shall comply with section 8.4.3 (electrical energy monitoring) of the most current ASHRAE 90.1 standard, and any other code requirements.*
G. *Electrical meters shall be provided and integrated by the BMS contractor.*
   1. *All network integration shall comply with all other TG requirements outline in this document.*
   2. *All wire from the demark enclosure shall be provided by BMS contractor.*
   3. *BMS contractor must provide direction to the electrical trade for current transducers to meet the requirements for the BMS provided sub meter.*
H. *Demark enclosure shall be provided by the electrical trade including:*
   1. *Circuit breakers (as required).*
   2. *Shorting blocks for current transducers (as required).*
   3. *Enclosure for demark point.*
   4. *Current transducers, as required to connect to the BMS provided sub meter (coordinate with the BMS trade).*
I. *Please reference electrical specification section 1.1 for additional information.*
J. *Metering is required as defined in section 26 27 13.*
K. *Basis of design and base approved vendor is*
   1. *Setra Power Meter.*
   2. *Siemens / Dent Instruments*
   3. *Approved Alternative*

5 BMS SOFTWARE, DATABASE AND PROGRAMMING REQUIREMENTS

5.1. General

A. The BMS NDS shall be provided complete with fully functional, advanced, BMS Application Software and Database facilities in compliance with the UBC requirements. The building BMS Contractor shall provide all required programming, database development, and data communication configuration work required to incorporate new campus building BMS installations.

5.2. System Requirements

A. The NDS computer shall provide the capabilities for automatically archiving controller programming and database, receiving and archiving all operator transactions, trending and archiving of defined BMS data, etc.

B. The NDS computer shall be provided by UBCO IT Services. Specific hardware allocation requirements for the NDS to be coordinated between the BMS vendor and UBCO IT.

C. The NDS and associated application specific BMS Software shall be provided with programming and configuration facilities to allow BMS operators to undertake BMS administration functions including the following:

1. Add/delete/modify data points and input/output points.
2. Configure controller data communications.
3. Add or modify automatic sequence of operations programs, database, etc.
4. Change control system data parameters.
5. Modify set points, etc.
6. Restore/download programming and database parameters to BMS controllers.

D. BMS installations shall be provided in a completed state fully ready for integration to the CBMS including all data point definition, addressing, naming, network configuration/connection, documentation, commissioning and training.

E. BMS installations shall be in compliance with the following requirements and shall provide the following functionality:

1. All BMS and CBMS controllers and operator interface workstations shall be devices that are conformal with the BACnet standardized device types described in Annex L of the ASHRAE Standard 135. BMS devices shall, at minimum, support the BIBB's (defined in Annex K of ASHRAE Standard 135) and the associated functionality that are defined as a functional requirement for the device in Annex L of the ASHRAE Standard 135.
2. All BMS controllers, regardless of their device type, shall communicate on the BMS and CBMS networks and shall be "visible" to the CBMS and BMS networks.
3. BMS data shall comply with the BACnet data object property requirements and, at minimum, shall support the properties defined in ASHRAE Standard 135 as "required".
4. All physical BMS monitored input points (binary and analog type) shall be readable and available for monitoring at the CBMS and by other BMS controllers.
5. All physical BMS controlled output points (binary and analog type) shall be readable and available for monitoring at the CBMS and by other BMS controllers and shall be writeable and shall be capable of being controlled/positioned by the CBMS and by other BMS controllers.

6. All software data points and control system parameters critical to the supervisory monitoring and control of the building systems shall be available for monitoring at the CBMS and by other BMS controllers and/or shall be writeable and shall be capable of being controlled/positioned by the CBMS and by other BMS controllers. Provide the following typical software data points and control parameters with the defined functionality, at minimum.

F. The BMS Specifications shall identify additional points and functionality where required.

1. System enable virtual points.
2. Virtual or "logical" software points.
3. Equipment and System operation Calendar/Time Schedule points and parameters.
4. Post Fire Alarm System Enable/Disable points.
5. Post Power Failure System Enable/Disable points.
6. Control loop set points and PID loop values.
7. Alarm set points and alarm limit parameters.
8. Define and modify alarm states and alarm limit threshold values for any monitored analog and digital input points and for analog output values.

G. BMS data shall be presented in both tabular "report" format and in dynamic graphical display format at the CBMS. Provide the CBMS with the capabilities for the operator to select between report and graphical data display mode.

H. Modification of the controlled output points shall be via operator interface at the CBMS dynamic report and graphical interface facilities and shall not require BMS manufacturer proprietary software or special configuration software files.

I. All BMS standard and proprietary data objects from any BMS connected device shall be available for monitoring on the BMS and CBMS. Values for all BACnet defined required property values, supported optional properties and proprietary properties shall be available to the BMS and CBMS for monitoring and display and control where applicable.

J. The BMS Specifications for each building BMS project shall specify the requirement for the BMS Contractor/Manufacturer to provide all hardware and software required for the CBMS to communicate with the BMS via BACnet IP on the UBC campus WAN. Facilities to be provided shall include any manufacturer specific software tools required for programming, point mapping, configuration, etc. of building BMS data points.

K. Trending: The BMS contractor shall setup and configure system trending as follows:

1. In general, all DDC system points shall be trended and each trend log point shall be minimum 200 samples. Trend logs shall be set up to meet the following requirements:
   a. Storage:
      I. All panels that store trends must be able to store 2 days of *300* second sample rates for all attached physical points.
      II. All long term storage devices shall be able to store 3 years of trend data.
      III. All district energy and metering points shall be connected to the Siemens Desigo BMS.
   b. Sample Frequency:
      I. Sample frequencies shall be configured to gather meaningful data required to analyze system performance, confirm loop tuning, and aid system troubleshooting.
      II. AI, AO and AV default trend sample rate shall be 300 seconds.

III. BI, BO and BV items shall be trended on change of value.
IV. MV shall be trended on change of value.

2. Trended Points:
   a. All physical input and out points.
   b. All effective set point values (this is to include loop set points, high and low limit set points, and all room set points, which can be trended at a relaxed rate).
   All multi-state mode points, trended on change of value.

L. Data Archiving: The BMS contractor shall install, configure and program the DAU. The DAU shall be configures as follows:

1. Every physical point shall be archived,
2. Every software variable that is used for day to day operations shall be archived,
3. The archival time period shall be set for five (5) years.
   a. The DUA device or system shall automatically prune all data that has aged beyond the five year time limit.
4. All alarms shall be archived. Alarms shall be archived to include the following information:
   a. All alarms shall include the following identification; DCC Network Descriptor acronym
   b. Expanded DDC Network Descriptor,
   c. Date
   d. Time
   e. Point Name
   f. Expanded Point Descriptor
   g. Alarm Type (e.g.: Operating, Maintenance, Critical, Emergency, etc.)
   h. Alarm Status
   i. Automatic Control Priority (Overridden Value, Automatic Control, Disabled, failed, etc.)
   j. Actual point monitored input / controlled output value.
   k. Alarm Set point
   l. Alarm Message.

5.3. SOFTWARE

A. An operator with BMS configuration software shall be able to define a minimum time delay between successive starts of equipment so that disturbances created on the building electrical system are minimized in frequency and amplitude.

B. An operator with BMS configuration software shall be able to define the minimum time delay between the stopping of a piece of equipment and its subsequent restart. This time delay shall be in effect for motors in the BMS software control mode and for motors in the BMS manual control mode.

C. The BMS shall not override any hardwired interlocks such as those provided at motor starters for overload protection, damper interlock, pressure interlock, etc. and those provided to facilitate control by the Fire Alarm System regardless of the BMS output control mode.

D. Unless stated to the contrary, the modulation of final control elements by the BMS in the BMS software control mode shall be based on a Proportional-Integral (PI) or Proportional-Integral-Derivative (PID) control algorithm. The control constants for the PID algorithm shall be definable by the operator. If self-tuning algorithms are provided, it shall still be possible for the operator to manually tune the control loops. The software shall incorporate facilities

to enable the bump less transfer of a modulating output from BMS manual control to BMS software control and vice versa and the prevention of integral wind-up. PID algorithms shall maintain the system operation within the desired tolerance around the set point.

E. Provide run time totalizing software facilities at both the CBMS and BMS NDS that will accumulate the operating times for motors and unitary equipment as selected by the operator using an interactive procedure. Any piece of equipment that has its status monitored by the BMS shall be selectable for inclusion in this feature. It shall be possible to concurrently monitor the accumulated operating time for every item of equipment monitored and/or controlled by the BMS. Historical trend data shall be stored in a non-proprietary database such as Microsoft SQL Server in the BMS NDS.

F. Provide demand limiting and duty cycle programs that will duty cycle equipment usage in a manner that conserves energy. The cycling of equipment shall be initiated by one of the following means:
1. Operator defined schedule.
2. Peak electric demand control software program.
3. Operator manual command.

G. The proportion of ON time to OFF time in a single cycle shall either be assigned by the operator using an interactive procedure or the operator may elect to have a variable ON/OFF ratio based on other criteria.

H. Provide a scheduling program that will enable the BMS to automatically schedule an item of equipment on and off (occupied) and on and off (unoccupied) based on time to allow, for example, the AHU to operate with the outside air dampers closed during non-occupied time periods, etc. The operator shall be able to assign a minimum of four start and four stop times to each piece of equipment for each day of the week and for holidays. These schedules shall only be in effect for a piece of equipment when it is in the BMS software control mode. Equipment and space time occupancy time schedules shall be available for display and operator adjustable via the CBMS. The scheduling feature shall conform to the CBMS scheduling interface.

I. Provide equipment fail restart software that will restart equipment shut down as the result of a fire alarm system following the return to normal conditions or a power fail condition.

J. Provide a night setback software program that shall match ASHRAE 36.1 standard, refer to Section 20 00 30 2.6 for indoor thermal requirements for occupied and unoccupied spaces.

K. Provide facilities for alarm notification via both the building BMS NDS and the CBMS via e-mail messaging, wireless text messaging and SNMP.

6 CBMS SOFTWARE, DATABASE AND PROGRAMMING REQUIREMENTS

6.1. INTEGRATION OF STANDALONE BUILDING BMS INTO THE CAMPUS BMS

A. The CBMS Contractor shall provide the mapping, storage, and reporting of the building BMS monitoring and control objects into the CBMS and the preparation of data presentation for the CBMS Management Level Network. The BMS Contractor shall provide to the Owner and to the CBMS Contractor, all necessary documentation, BIBB information, device addressing, etc. as required for the integration of the BMS monitoring and control functions into the CBMS.

B. The CBMS Contractor shall integrate all trend logging and trend log archiving set up in the building BMS into the CBMS.

C. The CBMS Contractor shall set up, configure, and prepare the HDAS to import all integrate all trend logging and trend log archiving set up in the building BMS DAU(s) into the HDAS. This shall include creating the capability to setup, configure, and review historical data obtained from the BMS in a graphical trend log format.

6.2. CBMS DYNAMIC SYSTEM REQUIREMENTS

A. CBMS installations shall be in compliance with the following requirements and shall provide the following functionality:

1. All BMS and CBMS controllers and operator interface workstations shall be devices that are conformal with the BACnet standardized device types described in Annex L of the ASHRAE Standard 135. BMS devices shall, at minimum, support the BIBB's (defined in Annex K of ASHRAE Standard 135) and the associated functionality that are defined as a functional requirement for the device in Annex L of the ASHRAE Standard 135.
2. All BMS controllers, regardless of their device type, shall communicate on the BMS and CBMS networks and shall be "visible" to the CBMS and BMS networks.
3. BMS data shall comply with the BACnet data object property requirements and, at minimum, shall support the properties defined as "required" in ASHRAE Standard 135.
4. All physical BMS monitored input points (binary and analog type) shall be readable and available for monitoring at the CBMS and by other BMS controllers.
5. All physical BMS controlled output points (binary and analog type) shall be readable and available for monitoring at the CBMS and by other BMS controllers and shall be writeable and shall be capable of being controlled/positioned by the CBMS and by other BMS controllers.
6. All software data points and control system parameters critical to the supervisory monitoring and control of the building systems shall be available for monitoring at the CBMS and by other BMS controllers and/or shall be writeable and shall be capable of being controlled/positioned by the CBMS and by other BMS controllers. Provide the following typical software data points and control parameters with the defined functionality, at minimum. The BMS Specifications shall identify additional points and functionality where required.
    a. System enable virtual points.
    b. Virtual or "logical" software points.
    c. Equipment and System operation Calendar/Time Schedule points and parameters.
    d. Post Fire Alarm System Enable/Disable points.
    e. Post Power Failure System Enable/Disable points.

f. Control loop set points and PID loop values.
g. Alarm set points and alarm limit parameters.
h. Define and modify alarm states and alarm limit threshold values for any monitored analog and digital input points and for analog output values.

7. BMS data shall be presented in both tabular "report" format and in dynamic graphical display format at the CBMS. Provide the CBMS with the capabilities for the operator to select between report and graphical data display mode.
8. Modification of the controlled output points shall be via operator interface at the CBMS dynamic report and graphical interface facilities and shall not require BMS manufacturer proprietary software or special configuration software files.
9. Performance times shall be as follows:
   a. Data values updated in dynamic report or graphical display reports within maximum interval of 5 seconds.
   b. Defined high priority or critical alarms annunciated within 3 seconds of its sensed occurrence.
   c. CBMS Operator command outputs and data point modifications shall be executed within 5 seconds of the command initiation at the CBMS workstation or other remote BMS device.
   d. Failed BMS/CBMS data communications or controller device on the Management Data Communications Level or the Automation Data Communications Level within ten (10) seconds.

B. All BMS standard and proprietary data objects from any BMS connected device shall be available for monitoring on the BMS and CBMS. Values for all BACnet defined required property values, supported optional properties and proprietary properties shall be available to the BMS and CBMS for monitoring and display and control where applicable.

6.3. CBMS DYNAMIC SYSTEM GRAPHICAL INTERFACE REQUIREMENTS

A. The work of BMS installation projects in UBC Buildings shall include the integration of the building BMS facilities into the CBMS. The integration of the individual building BMS into the campus BMS shall include the provision of Dynamic BMS System Graphical Interface. All graphics will be a clear representation of all BMS monitoring and control facilities/systems within the building. The BMS Designer shall specify detailed requirements for the BMS Graphic Schematics in the BMS/CBMS Design Documents.

B. The CBMS System Graphics shall be fully dynamic colour graphics. One graphic shall be provided for each BMS monitored/controlled system. Miscellaneous HVAC and electrical values monitored by the BMS shall be displayed in graphic displays of logical groups of equipment.

C. Graphics shall be provided by the CBMS Contractor and fully integrated into the campus BMS. CBMS System Graphics shall be capable of being displayed at any OWS simultaneously.

D. CBMS System Graphics shall be developed based on UBC standard graphic symbols and colours. All BMS system graphics shall be coordinated with UBC. The Contractor shall submit copies of proposed graphics in the shop drawings for review and approval by the BMS/CBMS Consultant and UBC. The Contractor will submit individual graphical screenshots of all systems in a fully commissioned state.

E. CBMS System Graphics shall include the following requirements:

1. Graphics shall be as per standards coordinated with the UBC-BMS group standards

that are in place.
2. Graphics shall be vector based and scalable for different sized displays.
3. Default display size for design shall be 4k, 24" display.
4. Supplied graphics package should be continuously improved over time.

F. Equipment/devices shall be colour coded as follows:

Red/Dark red	Hot Water piping (supply/return)
Blue/Dark blue	Chilled Water piping.
Green/dark green	Condenser Water piping.
Yellow/gold	DES hot water
Yellow/Green	Glycol

G. BMS analog input and analog output point information shall be displayed as follows:

1. Point Name
2. Automatic Control Priority (Overridden Value, Automatic Control, Disabled, failed, etc.)
3. Actual point monitored input / controlled output value.

H. BMS digital input and digital output point information shall be displayed as follows:

1. Point Name.
2. Automatic Control Priority (Overridden On/Off, Automatic Control, Disabled, failed, etc.)
3. Point status.

I. BMS System Graphics shall be provided as follows:

1. Floor Plans for all building project areas. One graphic per floor level. Floor plans shall indicate the associated AHU service domains. AHU Service domains shall be colour coded, as follows:
   a. Mechanical room #FF6B8E23 (Olive)
   b. AHU-01: #FF6495ED (Cornflower blue)
   c. AHU-02: #FF8A2BE2 (Blue violet)
   d. AHU-03: #FF7FFF00 (Chartreuse)
   e. AHU-04: #FF00FFFF (Aqua)
   f. AHU-05: #FF006400 (Dark green)
   g. AHU-06: #FF8B0000 (Dark red)
   h. AHU-07: #FF8B0000
   i. AHU-08: #FFFFD700
   j. AHU-09: #FFFF4500
   k. AHU-10: #FFEE82EE
   l. AHU-11: #FFADFF2F
   m. AHU-12: #FFFF0000 (Red)
   n. AHU-13: #FF00FF7F (Spring green)
   o. AHU-14: #FFFFC0CB (pink)
   p. AHU-15: #FF0000CD (medium blue)
   q. AHU-16: #FFF0E68C (khaki)
   r. AHU-17: #FF708090 (slate grey)
2. Space temperature, relative humidity, static pressure, air quality sensors, etc. mounted throughout the project spaces shall be displayed on the floor plan system graphic.
3. Building areas equipped with BMS zone space temperature control facilities shall have a dynamic link to a separate individual graphic for each terminal unit

controller.

4. Floor plans shall reflect normal/alarm status for BMS monitored/controlled points based on the following colour codes:

a.	Green	-Device On and operating under "normal" automatic control priority
b.	Yellow	- Critical Alarm Condition.
c.	Blue	- Device Off and operating under "normal" automatic control priority
d.	Orange	- General Alarm Condition.
e.	Aqua Blue	- Point Trouble Condition.
f.	Red	- Immediate Response Alarm Condition.

5. BMS System Graphic shall be provided for each Mechanical and Electrical Equipment Room indicating the BMS monitored/controlled equipment locations.

6. BMS System Graphics shall be provided for all BMS monitored/controlled equipment mounted on building rooftops and exterior building areas.

7. Outside Air Temperature and Relative Humidity shall be displayed on all HVAC System graphic schematics.

8. *BMS System graphics shall be schematically accurate. Simplified hydronic schematics are not acceptable.*

6.4. ALARM MANAGEMENT AND ANNUNCIATION

A. Alarms shall be generated by the BMS and shall be annunciated at the CBMS upon the occurrence of one of the following events:

1. Failure of a CCP, DCP, UC, or any other BMS hardware components.
2. Failure of communications or devices on the Automation Level Network.
3. A monitored status indicates a discrepancy between the actual and the required value.
4. A monitored value does not meet criteria established by the operator.
5. The deviation of a variable from set point exceeds operator established criteria.
6. The output to a final control element is outside operator established criteria.
7. A digital input is in the state defined by the operator as indicating an alarm condition.
8. Software failures and errors shall be diagnosed and annunciated by the BMS.

B. Provide configuration of alarming for all monitored and controlled points. BMS Specifications shall detail all required alarm states, values and limits.

C. BMS alarms shall be assigned priority levels as follows:

1. Priority Level 1 (64 to 95)– Critical Alarms:
   a. Sump high level status event
   b. Fire Alarm status event
   c. AHU low temperature detection device event
   d. Main Breaker power fail status event
   e. Generator fault condition
   f. Diesel Tank Storage Tank leak detection event.
2. Priority Level 2 (96 to 127) – All Non-Critical Alarms
3. Priority Level 3 (128 to 191) – Room temperature off setpoint alarms

D. Defined BMS alarm events shall be communicated by the BMS to the CBMS. Defined alarms shall be annunciated at the CBMS workstation. Alarms shall be retained in the CBMS alarm summary.

E. All alarms shall have the ability to include the following identification;

1. DCC Network Descriptor acronym
2. Expanded DDC Network Descriptor,
3. Date
4. Time
5. Point Name
6. Expanded Point Descriptor
7. Alarm Type (e.g.: Operating, Maintenance, Critical, Emergency, etc.)
8. Alarm Status
9. Automatic Control Priority (Overridden Value, Automatic Control, Disabled, failed, etc.)
10. Actual point monitored input / controlled output value.
11. Alarm Set point
12. Alarm Message.

F. The alarm log shall have the capability to be sorted or filtered on any or all of the following values:

1. DCC Network Descriptor acronym
2. Alarm Message.
3. Time
4. Date
5. Point Name
6. Alarm Type (e.g.: Operating, Maintenance, Critical, Emergency, etc.)
7. Automatic Control Priority (Overridden Value, Automatic Control, Disabled, failed, etc.)
8. Alarm Status

6.5. CBMS/BMS ALARM HANDLING ARCHIVING REQUIREMENTS

A. The CBMS shall automatically update the HDAS with the alarm message log on a daily basis.

B. The HDAS shall maintain a historical alarm log that encompasses all alarms for a period of five years.

C. The historical alarm log shall be searchable and have the capability to be sorted or filtered on any or all of the following values:

1. DCC Network Descriptor acronym
2. Alarm Message.
3. Time
4. Date
5. Point Name
6. Alarm Type (e.g.: Operating, Maintenance, Critical, Emergency, etc.)
7. Automatic Control Priority (Overridden Value, Automatic Control, Disabled, failed, etc.)
8. Alarm Status

D. The database sorting and filtering keys shall be a minimum of three levels deep.

6.6. TESTING AND COMMISSIONING REQUIREMENTS

A. Integrated BMS/CBMS joint systems tests shall be undertaken to demonstrate that the interaction between the individual building BMS and the CBMS meets the UBC requirements. The BMS Subcontractor shall participate in joint verification of the integrated systems and cooperate with the Owner in the demonstration of the integrated systems.

B. The BMS Specifications shall specify the requirements for the BMS/CBMS integration joint systems verification in the BMS and CBMS Specifications and/or Contract Documents. The BMS/CBMS Integrated System Verification shall include the following minimum requirements:

1. Test all BMS monitored and controlled field devices, BMS data points and all BMS input and output points. CBMS monitored data point values shall be verified against actual field device position/state and compared to BMS values to ensure both BMS and CBMS values are the same.
2. CBMS override control of all BMS output points and control data points shall be verified.
3. BMS network and controller device status and data communications status are accurately monitored at the CMBS. Alarms for failed controllers and failed data communications are annunciated.
4. BMS data values displayed on dynamic system graphics or in tabular data format at the CBMS are functional and accurate.
5. CBMS operator control of BMS control output points and control data points is functional via the dynamic graphic interface.
6. CBMS facilities for operator adjustment of alarm definition parameters and thresholds, set point adjustment, control parameter adjustments, point trend initiation and modification to trends, etc. are fully functional.
7. The CBMS performance requirements for the monitoring and control of BMS data and field devices meet the UBC requirements.
8. BMS device addressing and identification definitions are compatible and identical and the addressing scheme meets with UBC requirements.
9. Point naming used is compatible and conformal with the UBC requirements.

C. Test results shall be documented using test sheets. The test sheets shall be prepared in an appropriate format for the various categories of component and system to be tested. It is the responsibility of the BMS Subcontractor to provide test verification sheets for each component and system that accurately reflect the sequences of operation and appropriate data for the components and systems.

D. All test documentation shall be maintained in electronic format.

6.7. UBCO BMS POINT NAMING CONVENTIONS REQUIREMENTS

A. All point naming conventions shall be reviewed and accepted by the UBCO Energy Team.

B. Each point name shall follow a consistent format. See Appendix A for detail on point naming conventions.

C. Contact UBCO Energy Team for more detailed point naming

D. Coordinate with BMS manager for final point naming.

6.8. UBC BMS CONTROLLER AND DEVICE ADDRESSING AND NAMING CONVENTION REQUIREMENTS

A. All IP addresses are to be provided by UBCO personnel once the necessary IT infrastructure is in place.
   1. In the event of new building construction this infrastructure will not be in place until the building is near completion.

B. BACnet device addressing is to be managed by UBC-BMS group and should within the venders assigned address range as follows.
   1. Siemens:
      a. 100000 - 1199999
   2. Delta:
      a. 10000-99999

C. UBC personnel are to provide BACnet device addresses for devices outside of the assigned vender address ranges.

D. UBC personnel must be provided any necessary tools to change the BACnet device address on any devices installed.

7 GUIDELINES FOR APPLICATION OF BMS TO TYPICAL HVAC SYSTEMS

7.1. BMS Sequences of Operation, Field Termination Schedules, and System Schematic Diagrams

A. This section of the UBC BMS Design Guidelines identifies BMS monitoring and control requirements for typical building HVAC Systems and includes “sequences of operation” for typical building systems. BMS design specifications for all UBC BMS projects shall include BMS Sequences of Operation detailing the BMS monitoring and automatic control logic programming requirements. BMS Sequences of Operation to be provided in BMS Design Specifications shall be in the same format as the sequences of operation identified within these guidelines.

B. BMS Design Specifications for UBC BMS projects shall detail BMS monitoring and control requirements in Field Termination Schedules and System Schematic Diagrams. Field Termination Schedules and System Schematic Diagrams shall be provided for all BMS monitored and controlled equipment and systems. The Field Termination Schedules and System Schematics shall be provided for each building system and logical group of monitored and controlled equipment. The Field Termination Schedules and System Schematics shall clearly identify BMS monitoring and control requirements and shall be labelled and cross reference the associated sequences of operation.

C. Sequences of Operation for typical UBC building HVAC systems are identified within this section.

D. BMS automatic control of building systems and equipment shall not override life safety or equipment protection overrides. The BMS Design Consultant shall specify automatic control interface requirements.

7.2. BMS Component and Building Equipment Failure Requirements

A. The BMS Design Specifications shall clearly specify building system/equipment control requirements in the event of failure of BMS components and in the event of failure of building equipment. The following are general minimum component/equipment failure requirements.

B. DCP/UC Controller Failure
   a. associated BMS controlled electric motors/equipment off.
   b. AHU mixing dampers to full recirculation position.
   c. steam control valves closed.
   d. hot water control valves open.
   e. cooling coil control valves closed.
   f. fan/pump speeds set to minimum position.
   g. fan/pump volume flow rate control devices (e.g. inlet vanes, etc.) set to no-load position.
   h. isolation dampers closed.
   i. exhaust dampers and outside air dampers closed.

1. BMS Analog Input Sensor Failure

   a. Associated BMS control output retained in last commanded state. If an alternative sensor can be utilized for satisfactory control the BMS shall incorporate automatic control logic to implement the revised control.
   b. Failure of information only type BMS input points shall be annunciated as alarms.

2. Controlled Electric Motor/Equipment Failure

   a. Anytime the status of BMS controlled equipment is different than the associated BMS controlled output status the equipment shall be considered as "failed" and shall be shut down by the BMS. The associated BMS controlled system shall also be shut down. **Project Design Specifications shall specify the post failure equipment restart requirements.**

   b. Where building systems/equipment are shut down by the by the fire alarm system in an alarm condition or are shut down as the result of a building power failure, the BMS shall restart the failed equipment/systems in an orderly and pre-defined manner following **the cleaning of the Fire Alarm or return to normal power.** The BMS Design Specifications shall specify the post fire alarm equipment restart and the post power failure equipment restart requirements.

   c. All BMS component failures shall be annunciated as an alarm at the defined BMS main central computer facility.

3. If a BMS controlled motor or equipment fails to start as defined in the sequences of operation, the failure shall be annunciated as an alarm and the associated system shut down.

7.3. BMS Automatic Sequenced Control of AHU Mixing Dampers and Valves

A. See ASHRAE 36.1 specification for standard AHU sequence of operations

7.4. General BMS Monitoring and Control Requirements

A. All BMS alarm limit values and set points shall be on-line adjustable by a BMS Operator with the appropriate password access level.

B. All BMS Operator monitoring and control functions shall be provided with the appropriate password access control.

C. A single BMS software control point shall be provided for each BMS controlled system to enable/disable automatic start-up and control of the entire system. BMS controlled systems shall be capable of being started/stopped either by automatic BMS control or via online Operator command.

7.5. Post Fire Alarm Equipment Restart

A. Fire Alarm Systems in buildings will override BMS control of designated equipment in an alarm condition. The BMS shall monitor a set of contacts output from the fire alarm system for status indication of a building fire alarm. The BMS Controls Contractor shall coordinate building equipment that is shut down by the Fire Alarm System.

B. Upon detection of air handling unit shutdown the BMS shall close associated valves and stop associated pumps.

C. Alarms shall be annunciated by the BMS to indicate the equipment failure/shut down and the building fire alarm condition. The BMS shall not annunciate nuisance alarms for monitored input points on systems shut down by the BMS or fire alarm system (e.g. high supply air temperature, low duct static pressure, etc.).

Equipment shut down by the fire alarm system shall be automatically restarted once the fire alarm condition

is cleared at the fire panel.

D. Once the building fire alarm is cleared, the restart sequence shall provide an orderly start-up of the motors for each individual system with time delay between restarts of individual systems. Start of systems shall be according to normal system start up sequences. Only those motors which should be operational in accordance with the Occupancy Schedule or application software programming requirements shall be restarted.

7.6. Post Building Power Failure Equipment Restart

A. Power failures in buildings will result in building equipment shutting down. The BMS shall monitor building electrical distribution equipment status for indication of a building power failure condition. Some building equipment will be serviced with stand-by power and UPS power supplies. The BMS Controls Contractor shall coordinate building equipment that is serviced with stand-by and UPS power supplies.

B. Post Building Power Failure Equipment Restart facilities shall be provided to ensure the controlled and orderly startup of building equipment following a power failure. The Post Building Power Failure Equipment Restart facilities shall be provided based on the requirements identified above for the Post Fire Alarm Equipment Restart.

7.7. Air Handling Unit Optimum Start and Stop Programs

A. Air handling optimal start shall be as per the individual controls contractors standard optimal start logic.Utilize pre-schedule warmup and night setback routines as a minimum.

7.8. Air Handler Wifi-Occupancy Program

A. UBCO Employs the use of a Wifi Occupancy system to optimize the scheduling of Air Handling Units based on building space usage. A Chipkin BACnet Gateway provides occupancy count data for each air handling building area on a floor by floor basis. The controls contractor shall integrate with the Chipkin Wifi Occupancy Gateway to provide the following sequencing and alarms.
   1. If the total count from all floors is above a maximum “on count” threshold of 5 or more (adj) for 15 minutes (adj), the AHU will be enabled for occupied operation.
   2. If the total count from all floors is less than a minimum “off count” threshold of 2 (adj) for 15 minutes and the average room temperature is within 3 deg C of the average room set-point of 21 deg C (adj) the AHU will shut off. If the total count from all floors is less than the minimum threshold for 15 minutes and the average room temp is not within 3 deg C of the average room set-point (adj) the AHU will remain in operation until the room temperature is within 1 deg C (adj) of set-point.
   3. The Wifi Occupancy takes priority over the air handler Occupancy schedule. When space is unoccupied, setback heating and optimized start sequences remain active.

B. The following alarms shall be implemented for Wifi Occupancy Operation
   1. The Chipkin gateway device includes a heartbeat point that toggles every 5 minutes. Alarm at the BMS when the DDC does not observe a change of state in the heartbeat point for 1 hour. When this alarm occurs, the air handler unit shall operate by the regular occupancy schedule, disregarding the Wifi Occupancy count values.
   2. The heartbeat alarm will stay active until reset by an operator at the BMS Graphics. The alarm will also auto-reset daily at 8 am if the heartbeat point is actively toggling. Verify by monitoring the heartbeat point to see if state has changed in the last 10 minutes.
   3. The BMS shall monitor the total wifi counts for each building to monitor for communication errors. If the total count value has not changed for 6 hours an alarm will be generated.
   4. A Wifi alarm reset for each building is present on each WIFI overview graphic. When activated the heartbeat alarm is turned off and all timers are set at zero.

C. Overview graphic for wifi occupancy operation shall follow UBCO standard graphic format.

7.9. After-hours Equipment Operation

A. Designated air handling systems shall be off during Unoccupied Periods if all space temperatures are above 15 ° C. If any space temperature falls below 15 ° C. the system shall be started and operate with the mixing dampers in the full recirculation position, the heating pump on and the heating coil valve fully open to flow through the coil. The system shall return to the off position as described in B. above when all space temperatures are above 16 ° C.

7.10. Air Handling Unit Supply Air Temperature Reset Schedules

A. See ASHRAE 36.1 specification for count based discharge air temperature reset sequence of operations.

7.11. Dynamic Mixed Air Calculations and Mixing Damper Minimum Outside Air Positioning

A. BMS mixed air calculation shall take into account the cascaded discharge air temperature, the outdoor air temperature, the return air temperature, and zone or return air CO2 levels.

7.12. Typical Sequence of Operation - Variable Volume Air Handling Unit

A. Refer to ASHRAE 36.1 for sequence of operations

7.13. Typical Sequence of Operation - VAV

A. Refer to ASHRAE 36.1 for sequence of operations

7.14. Chilled Water (CW) and Condenser Water (CSR) Systems

A. Sequences are dependent on installation.

7.15. Supply Hot Water System (SHW)

A. Sequences are dependent on installation.

7.16. Domestic Hot Water System

A. Sequences are dependent on installation.

7.17. Campus Level Peak Demand Limiting

A. The Campus level PDL is triggered by monitoring the Campus kVA usage and activating the Campus level PDL when power usage exceeds the user defined threshold limit. The on/off PDL toggle is based on a percentage (user adjustable) of the current month threshold value. Threshold Limit (TL) On and off trigger values are calculated by multiplying the current month Threshold limit by the TL On or off Percentage. The differential between the TL On & TL Off values helps prevent the PDL from cycling on and off. Once the PDL has reached the TL Off value for a period 1800 seconds (30 minutes) the Campus PDL can toggle off.

B. Campus Level PDL Active:
   1. All building level PDL points will be activated.
   2. Chiller Demand Limits will reduced 25% below the current chiller demand. Should the chilled water supply water temperature deviate by (5degC.) above the chilled water setpoint for (10min adj.), the demand limit will be raised by 25%. After 20min (adj.) should the chilled water temperature still be above set point by 5DegC then the chiller demand limit shall be raised another 25% to a maximum of 75%.

C. Campus Level PDL Normal:
   1. All building level PDL points will be deactivated.
   2. Chiller Demand Limits will put back to 100%.

7.18. Building Level Peak Demand Limiting

A. The Building level PDL is triggered by monitoring the building kVA usage and activating the building level PDL when power usage exceeds the user defined threshold limit. The on/off PDL toggle is based on a percentage (user adjustable) of the month threshold value. Threshold Limit (TL) On and off trigger values are calculated by multiplying the current month Threshold limit by the TL On or off Percentage. The difference between the TL On & TL Off values to help prevent the PDL from cycling on and off. Once the PDL has reached the TL Off value for a period 1800 seconds (30 minutes) the Building PDL can toggle off.
B. If the PDL conditions persist beyond 4pm the Building level PDL condition will stay active until midnight.

7.19. AHU Level Peak Demand Limiting

A. Each AHU has its own PDL enable point that is activated when either the ***Building*** *or* **Campus Level** PDL is active. This allows the operators to manually turn off PDL to specific equipment as required.
B. For air handling units with terminal equipment, the room setpoint shall be adjusted by a user-adjustable heating and cooling offset. The Setpoint will show a priority level of PDL while PDL is active (BACnet priority 14). The point will be released from PDL priority once PDL has toggled off as shown in Admin Graphic. For example: If a zone is in heating mode the room temperature setpoint will be ***decreased*** by 1 Deg C.
C. For air handling units without terminal equipment, the PDL will adjust the room setpoint. Heating or cooling operation of the air handler is determined by coil valve position.

7.20. Generators

A. Generator shall communicate operational data to the local network and be monitored by the BMS system.
   1. Data shall be available via BACnet IP or MS/TP only.
   2. Data shall include operational parameters such as production amps, volts, generator status, etc.
   3. Data shall include warning and emergency parameters such as overcrank, Not In Auto, Running, etc. Generator status points should be hardwired.
B. Provide gateway to translate modbus/RTU to modbus/TCP/IP to Bacnet IP as required.Transfer switch shall communicate operational data to the local network and be monitored by the BMS system.
   1. Data shall be available via BACnet IP or MS/TP only.
   2. Data shall include operational parameters such as Power Source (Utility/Generator), load power monitoring, Auto or manual operation, etc.
   3. Data shall include warning and emergency parameters such as switch in manual, fail to transfer, common fail alarm.
   4. Provide gateway to translate modbus/RTU or modbus/TCP to BACnet IP as required.

7.21. Variable Frequency Drives (VFDs)

A. *Variable frequency drives shall be controlled via hard-wired DDC only. VFDs shall include the following minimum required control points:*
   1. *BI – Drive Run Status*
   2. *BI – General Alarm*
   3. *AO – Control Speed*
   4. *BO – Drive Enable (Start/Stop)*
B. VFD communication interface is recommended to be RS485 MS/TP. Communication interface shall not be used to operate the drive. At minimum, the following values shall be communicated to the BMS:
   1. Drive run hours

2. Power demand in kW
3. Power consumption in kWh

***** END OF DESIGN GUIDELINES*****