DIVISION 25 – INTEGRATED CONTROLS

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25 00 01. GENERAL:

1. Instrumentation & Controls specifications shall be properly coordinated with Division 03 Heating, Ventilation and Air Conditioning and shall conform to the format and organizational requirements stated in the introduction of these standards.

2. All value engineering (VE) items, materials and methods shall be identified during the conceptual design phase. These shall be reviewed by the EM and shall be incorporated in the design by the engineer of record.

25 00 02. SCOPE:

1. Furnish all labor, materials, equipment, service, and training necessary for a complete, operational, and fully commissioned direct digital control (DDC) system for the facilities identified in the contract documents. The system shall use the BACnet protocol ANSI/ASHRAE 135-2012 at the IP and MS/TP level of the architecture. Conformance under ANSI/ASHRAE 135-2012, 135-2016 and 135-2020 is also acceptable. Web services at the supervisory controller and/or PC server level is also required. See Appendix A for a complete list of Web Services requirements. The introductions of BACnet SC (Secure Connect) within any device must be approved by University of Minnesota's Owner Representative.

2. Furnish all labor, materials, equipment, service, and training necessary to integrate the proposed DDC system into the existing University of Minnesota Public Safety Emergency Communications Center (PSECC) BACnet alarm receiver. The primary communications protocol used by University of Minnesota is BACnet/IP at the Supervisory controller and Web services from the vendor specific PC web server. Existing LON and BACnet MS/TP may be used at the inter building level only, provided that the supervisory controllers communicate using BACnet/IP on the existing University of Minnesota LAN which is Ethernet based. The Addition of new LON components for reasons other than integrating existing LON devices into new architecture is prohibited.

3. Furnish a minimum of one (1) licensed copy of all software including all software tools required for programming, commissioning, graphic modification, and control logic modification. All programming/graphic tools must be pre-approved by University of Minnesota automation group. Contractor shall assist the automation group with software installation on the University of Minnesota server and/or U of M owned laptop computer.

4. The controls contractor shall include all items which are reasonably necessary to complete the installation even though not specifically mentioned in the Contract Documents.

5. Temperature control panels and/or enclosures in equipment rooms shall be located at readily accessible locations approved by University of Minnesota's Owner Representative.

6. The control system "As-Built" drawings that show all devices and wiring and the sequence of operation shall be accessible through links on the Web Browser graphic page.

7. University of Minnesota owns and operates a Public Safety Emergency Communications Center (PSECC) which provides central monitoring of critical HVAC systems, fire, security, and life safety systems, for approximately 250 U of M owned facilities. Each addition and/or alteration to a building control system shall work on the University of Minnesota LAN utilizing BACnet/IP as the primary inter building protocol.

    7.1. PSECC is presently located at: Transportation and Safety Building 505 Washington Ave SE University of Minnesota

8. Temperature Control Contractors must work directly with the U of M IT department to acquire access to the U of M LAN including the Energy 01 VLAN. It is the responsibility of the Controls Contractor to ensure that all U of M's IT requirements are met before any Ethernet based DDC system is bid on.

9. All building level devices must communicate using BACnet/IP and must support the requirements listed in this specification. The University of Minnesota is committed to integration so that point status and automatic control, alarming and fault detection can be channeled into a common protocol. The University of Minnesota has established BACnet/IP and or BACnet MS/TP as the common protocol.

10. University of Minnesota DDC System Functions

    10.1. The general categories of the automated capabilities of University of Minnesota DDC system are:

        1A. Monitoring and Scheduling: Includes starting, stopping, observing, and reporting the operating status.

        1B. Intervention: The ability to automatically or manually shift to an alternate operating mode when conditions warrant it from a remote location.

        1C. Integration: The ability to coordinate the operation of several systems within a building, or several buildings, to ensure efficient operation.

        1D. Management Information: The ability to provide cumulative operating data such as system run time, units of energy consumed, and preventive maintenance schedules.

10.2. All DDC systems must be capable of functioning in the following modes:

2A. All life safety and building system objects shall be monitored and controlled, including equipment scheduling, via (BACnet/IP).

2B. System alarms shall be transmitted from each BACnet Supervisory controller to a BACnet recipient using intrinsic and/or algorithmic (event enrollments) alarming methods.

2C. University of Minnesota personnel shall have the ability to at a minimum: control set points, change alarming properties, and time schedule program modifications from the U of M BAS workstation or through any third party BACnet/IP workstation.

11. BACnet Integration:

11.1. Due to the complexity and size of University of Minnesota BACnet based system, integration requires stringent cooperation between University of Minnesota Facility Services and the selected Temperature Controls Contractor. University of Minnesota requires direct communication with the manufacturer's highest level of customer support and may need to converse with the manufacturer's BACnet development team during project design, implementation, commissioning, and warranty phases.

11.2. The University of Minnesota is committed to integrating different manufacturer’s temperature control systems on a common LAN for all existing and future temperature control systems that may be installed. University of Minnesota BACnet required conformance is limited to B-Side or BACnet building controllers, only. The Temperature Controls Contractor must provide labor, software, materials, wiring, network coordination and expertise to install Web Based BACnet Building Controllers and/or BACnet MS/TP and BACnet/IP field level controllers.

11.3. BACnet/Web Services communication shall be via the University of Minnesota LAN supplied directly from the building level controllers or vendor information PC server without having to route or convert it from a proprietary source. When building level network controllers are used for core BACnet communications, the field level panels on its sub-LAN, such as VAVs and unitary level controllers, can utilize BACnet MS/TP or BACnet/IP

11.4. Building level network controllers shall comply with all BACnet objects and properties requirements as listed in appendix A.

11.5. Contractor shall provide current BACnet Interoperability Building Blocks (BIBBs) and PICs Statements as part of the Control System Submittal review so BACnet conformance can be verified by the Engineer and Project Team prior to purchasing equipment.

11.6. BACnet conformance disputes that may arise in the Temperature Control Contractors installed BACnet Building Controller shall be resolved by the temperature controls Contractor working directly with the temperature controls manufacturer. Any required on-site device testing will be conducted using the BACnet International / BACnet Testing Laboratories (BI/BTL) Virtual Test Shell 3.6.7 or higher (VTS) program. Virtual Test Shell (VTS) is an application for testing the BACnet functionality of various devices used in building automation systems. Conformance issue fault will be agreed on and resolved using ANSI/ASHRAE Standards 135-2012 publication or higher depending on the device conformance.

11.7. No Gateways, Communication Bridges, Protocol Translators, or any other device that translates any proprietary or other communication protocol to the BACnet communication protocol shall be permitted as a part of the BAS installation pursuant with this specification section. Gateways may only be used as required for communication to existing systems or systems installed pursuant with other specification sections. This includes but is not limited to lighting control systems. It is the intent of the University of Minnesota to install only native BACnet communicating devices.

25 00 03. DEFINITION OF TERMS/ACRONYMS/ABBREVIATIONS

1. Additional definitions of terms or acronyms are included on the contract drawings and in other sections of this specification.

2. In the preparation of submittals and reports, the contractor shall use these definitions and abbreviations. Any terms or abbreviations used by the contractor in submittals and reports that have not been defined in this section shall be defined by the Contractor in the first section of the submittal or report prior to their use.

3. The following definitions serve as a guide for industry acronyms in the coming sections:

    3.1. ANSI - American National Standards Institute

    3.2. ASHRAE - American Society of Heating Refrigeration and Air Conditioning Engineers

    3.3. BACnet - Building Automation and Controls Network

    3.4. BACnet/IP – BACnet communications protocol via IP

    3.5. BIBBs - BACnet Interoperability Building Blocks

    3.6. BMA – BACnet Manufacturers Association

    3.7. BTL – BACnet Testing Laboratories

    3.8. CSV – Comma Separated Value

    3.9. DDC - Direct Digital Controls

3.10. EIA - Electronic Industries Association

3.11. IP – Internet Protocol

3.12. ISO - International Standards Organization

3.13. LAN - Local Area Network

3.14. LON - Local Operating Network

3.15. LONTalk - Open, published protocol.

3.16. LONWorks - A set of tools and components.

3.17. NIST - National Institute of Standards and Technology

3.18. PIC - Protocol Implementation Conformance Statement

3.19. VAV - Variable Air Volume

3.20. PSECC – Public Safety Emergency Communications Center

25 00 04. REFERENCES

1. The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

1.1. AIR MOVEMENT AND CONTROL ASPSECCIATION (AMCA)

1.2. AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

1.3. AMERICAN PSECCIETY OF HEATING, REFRIGERATION AND AIR-CONDITIONING ENGINEERS (ASHRAE)

1.4. ASHRAE 135-2012 BACnet Standard

1.5. FEDERAL COMMUNICATIONS COMMISSION (FCC)

1.6. INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

1.7. INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

1.8. NATIONAL ELECTRICAL MANUFACTURERS ASPSECCIATION (NEMA)

1.9. NATIONAL FIRE PROTECTION ASPSECCIATION (NFPA)

1.10. UNDERWRITERS' LABORATORIES (UL)

25 00 05. SUBMITTALS

1. Upon acceptance of a proposal, the controls contractor will provide submittal drawings for approval prior to ordering any equipment.

2. Copies of all required software shall be submitted to the Owner prior to the start of construction. No pay applications will be approved until all required software has been

received. Software includes all software needed to program all system components including PC applications, graphic creation, supervisory and sub controllers.

3. All new software not officially approved and currently installed at University of Minnesota must be vetted and approved by the University of Minnesota Automation Group prior to installation. It is imperative that all new software be submitted to the Owner as early as possible, but no later than with the Control System Submittal to avoid project delays. If the new software is not approved by University of Minnesota Automation Group, the Contractor shall provide an alternate solution that meets the University of Minnesota BAS Control Standard and is approved by University of Minnesota IT or risk forfeiture of the project.

4. A work schedule (implementation plan) shall be presented to the Owner before the start of work.

    4.1. All work shall be scheduled with the Owner to minimize building interruptions.

    4.2. Any service interruptions for making connections to the existing system shall be scheduled in advance with the Owner and only during periods approved by the Owner.

    4.3. The schedule shall include a timeline for hardware changes, software programming, communication connections, training, projected completion dates, etc.

5. If a conflict, error, omission, or lack of detailed description is discovered in the Contract Documents, the controls Contractor shall immediately notify the Engineer and Owner and request clarification. The Engineer and Owner will resolve the conflict and make any corrections or interpretations necessary to fulfill the intent of the plans and specifications.

6. Shop drawings shall be 11-inch by 17-inch, landscape, bound on the left edge. Organize the packages by building. All documents shall be submitted electronically in portable document format (PDF). At the request of the Owner, shop drawings will also be submitted in the native CAD format.

7. All text-based documents and product data sheets shall be 8 ½ inch by 11-inch format bound on the left edge. All documents shall be submitted electronically in portable document format (PDF).

8. Software files shall be submitted on fully labeled CDs that shall include a table of contents file in PDF format that provides a description of all of the files on the CD.

9. Submittals Prior To Construction

9.1. Shop Drawings - System Architecture Design Diagram

1A. The Riser Diagram shall show the IP layer and all of the Building Level MS/TP network layers.

1B. Riser Diagram shall show each computer, printer, router, repeater, controller, and protocol translator (for existing equipment only) that is connected to either the IP layer or any of the Building Level Net sub controllers.

1C. Where applicable, the Riser Diagram shall include the existing control system that is to be integrated into the new system (for existing equipment only).

1D. Each component that is shown shall have a name that is representative of how it will be identified in the completed database and the manufacturer's name and model number.

1E. The physical relationship of one component to another component shall reflect the proposed installation.

1F. Riser Diagram shall not include power supplies, sensors or end devices.

9.2. Layout Design Drawing for each control panel:

2A. The layout drawing shall be to scale with all devices shown in their proposed positions.

2B. All control devices shall be identified by name.

2C. All terminal strips and wire channels shall be shown.

2D. All control transformers shall be shown.

2E. All 120 VAC receptacles shall be shown.

2F. All IP connection points shall be shown.

9.3. Wiring Design Diagram for each control panel.

3A. The control voltage wiring diagram shall clearly designate devices powered by each control transformer. The diagram shall clearly show the consistent grounding of the appropriate power connection. All wire identification numbers shall be annotated on the diagram.

3B. The sub controller wiring diagram shall clearly show the use of the daisy chain wiring concept, the order in which the devices are connected to the building bus, and the location of end of segment termination devices. All wire identification numbers shall be annotated on the diagram.

3C. If shielded communication wiring is used, the grounding of the shield shall be shown. Shield drains will be grounded at supervisory controllers only.

3D. The terminal strip wiring diagram shall identify all connections on both sides of the terminal strip. Wiring label numbers for all wiring leaving the control panel shall be annotated on the diagram.

3E. Where pneumatic devices are monitored or controlled by the DDC systems, the control panel wiring diagrams shall include pneumatic piping diagrams for all components.

9.4. Wiring Design Diagram for each control panel.

4A. The wiring diagram for each component shall identify all I/O, power, and communication wiring and the locations on the terminal blocks to which the wires are landed.

4B. Installation Design Detail for each I/O device. A drawing of the wiring details for each sensor and/or end device. For devices with multiple quantities, a standard detail may be submitted.

4C. System Flow Design Diagram for each controlled system.

A. A two-dimensional cross-sectional diagram showing key components such as fans, coils, dampers, valves, pump, etc.

B. Identify the locations and names of all sensors and end devices that are associated with the control system. Label the panel name and terminal numbers where the connections are landed.

C. A legend shall be provided for all symbols used.

9.5. Alarm Matrix

5A. Alarm Matrix that lists all building alarm points.

5B. The matrix shall identify an alarm class for each alarm point.

9.6. Data

6A. Direct Digital Control System Hardware Technical Data.

A. A complete bill of materials of equipment to be used indicating quantity, manufacturer, and model number.

B. Manufacturer's description and technical data for each unique device to include performance curves, product specification sheets, and installation instructions. When a manufacturer's data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means.

6B. The most current BACnet Interoperability Building Blocks (BIBBs) and PICs Statements for all controllers.

6C. This requirement applies to: Controllers, Transducers/Transmitters, Sensors, Actuators, Valves, Relays and Switches, Control Panels, Power Supplies, Batteries, Operator Interface Equipment

9.7. An Instrumentation List for each controlled system.

7A. The list shall be in table format.

7B. Include name, type of device, manufacturer, model number, and product data sheet number.

9.8. Sequence of Control: A sequence of control for each system being controlled. Include the following as a minimum.

8A. Process control sequence for each end device.

8B. Supervisory logic sequence of control for each system.

8C. The impact of each global application program on the sequence of control (Example: Demand Control).

8D. A list of all physical inputs and outputs associated with each sequence.

8E. Within the sequence of control, all application parameters that are to be user adjustable from a BACnet operator workstation (OWS) shall be annotated with (adj) after the name of the parameter. This shall include set points, reset schedule parameters, calibration offsets, timer settings, control loop parameters such as gain, integral time constant, sample rates, differentials, etc.

8F. All points that shall be subject to manual control from an OWS.

8G. A list of all alarm points, a description of the alarm and a description of the alarm criteria.

9.9. Binding Map (to ensure distributed processing)

9A. A list of the device-to-device (peer-to-peer) data flow. This shall not include the flow of data from devices to the OWS.

9B. Include:

A. Description of the variable.

B. Sending device.

C. Receiving device.

9C. Software files for all new software not officially approved and currently installed at University of Minnesota. Software must be preapproved.

10. Submittals During Construction

1A. Training Manuals for each Training Course

A. Submit the following four weeks in advance of the training:

i. List of training objectives.

ii. Outline of the course with time allocations per topic.

iii. Training presentation material (slides, word documents, etc.).

iv. Copy of training reference material (product manuals to be used, etc.).

v. Schematic of the training equipment to be used with model numbers on each component.

vi. A description of the measurement devices to measure training effectiveness (quizzes, programming exercises, course exam).

vii. Instructor's name and resume with an emphasis on experience in presenting training programs.

1B. Startup Testing Plan: Submit a start-up testing plan for each unique system including pre-functional commissioning checklists.

A. The purpose of a startup test is to demonstrate the completeness of the physical tasks associated with installation and the performance of the components.

B. For each task on the startup test checklist, the plan shall require the technician to enter their initials and the date the test was completed along with any recorded data such as voltages, offsets, or tuning parameters. Any deviations from the submitted installation plan shall also be recorded.

C. Required elements of the startup testing include:

i. Measurement of voltage sources, primary and secondary.

ii. Verification of proper controller power wiring.

iii. Verification of component inventory when compared to the submittals.

iv. Verification of labeling on components and wiring.

v. Verification of connection integrity and quality (loose strands and tight connections).

vi. Verification of bus topology, grounding of shields and installation of termination devices.

vii. Verification of point checkout.

D. Each I/O device is landed per the submittals and functions per the sequence of control.

E. Analog sensors are properly scaled, and a value is reported.

F. Binary sensors have the correct normal position, and the state is correctly reported.

G. Analog outputs have the correct normal position and move full stroke when so commanded.

H. Analog outputs shall be tested to verify that any controlled pneumatic devices travel full stroke when the AO is varied from 0% to 100% output.

I. Binary outputs have the correct normal state and respond appropriately to energize/de-energize commands.

i. Documentation of analog sensor calibration (measured value, reported value and calculated offset).

ii. Documentation of Loop tuning (sample rate, gain and integral time constant).

J. Submit at least two weeks prior to equipment startup.

1C. Startup Testing Report

A. Startup testing reports shall be submitted on a per system basis.

B. Startup testing reports shall be the documented results of the executed startup testing plans.

C. Graphic Pages: Submit a sample graphic page for each type of page described in the specification section on graphic pages.

10.2. Submittals After Construction

2A. The following is a list of post construction submittals that shall be updated to reflect any changes during construction and re-submitted as "As Built". As-Built drawings will each be stamped "As-Built" and have the as-built date on them. The As-Built drawings will contain at a minimum:

A. System architecture drawing.

B. Detailed drawings for each piece of controlled and monitored equipment.

i. Layout drawing for each control panel.

ii. Wiring diagram for each control panel.

iii. Wiring diagram for individual components.

iv. Objects list.

v. Room Schedules.

vi. Sequence of operation.

vii. Hardware with part number information.

viii. System flow diagram for each controlled system.

C. Detailed routing of all communication trunk wires (building-to-building and within building), locations of all network and integration devices, front-end workstations, UPS and building network/LAN connections.

D. Binding map.

2B. Operation and Maintenance Manuals

A. The controls contractor shall provide one electronic (PDF) copy and three (3) bound copies of Operation and Maintenance Manuals.

B. Deliver manuals to the Engineer and University of Minnesota project manager.

C. Manuals shall be bound in heavy-duty, vinyl-covered, three-post, loose-leaf binders, permanently labeled on front and spine of each binder.

D. Arrange the manuals according to specification section numbers used in the Project Manual; include a table of contents that identifies the responsible installing contractor, contact person, and telephone number with area code and thumb tab index sheets.

E. Provide pocket folders for folded sheet information.

F. Maintenance and Operating Manual shall include the following type of information:

i. One copy of the executed Certificate(s) of Substantial Completion. This document will be used to communicate to all necessary University of Minnesota personnel the starting date of the one-year Warranty period.

ii. Signed record copy of bonds, guarantees, and warranties required by the Contract Documents.

iii. Manufacturer's required preventative maintenance inspections, testing, service,

lubrication, maintenance instructions, and schedules.

iv. Parts lists and local service organization.

v. As-built wiring and piping diagrams.

vi. System architecture diagram for components within the building annotated with specific location information.

vii. As-built drawing for each control panel.

viii. As-built wiring design diagram for each control panel.

ix. As-built wiring design diagram for all components.

x. Installation design details for each I/O device.

xi. As-built system flow diagram for each system.

xii. Sequence of control for each system.

xiii. Room schedules.

xiv. Binding map for the building.

xv. Product data sheet for each component.

xvi. Installation data sheet for each component.

xvii. Other information required by the Specifications.

G. The Contractor shall instruct University of Minnesota personnel in the use of Maintenance and Operating Manuals.

2C. Software

A. Submit a copy of all software installed on the servers and workstations.

B. Submit all licensing information for all software installed on the servers and workstations.

C. Submit a copy of all software used to execute the project even if the software was not installed on the servers and workstations.

D. Submit all licensing information for all of the software used to execute the project.

10.3. Project Closeout Submittals:

3A. The Temperature Controls Contractor shall advise the Owner throughout the duration of construction as to the status of the contract closeout

submittals including, but not limited to, the ongoing development of the maintenance and operations manuals and record documents.

25 00 06. OWNERSHIP OF PROPRIETARY MATERIAL

1. The University of Minnesota shall retain all rights to software for this project.

2. University of Minnesota shall sign a copy of the manufacturer's standard software and firmware licensing agreement. Such license shall grant use of all programs and application software to the Owner as defined by the manufacturer's license agreement, but shall protect the manufacturer's right to disclosure of Trade Secrets contained within such software.

3. The licensing agreement shall not preclude the use of the software by individuals under contract to the Owner for commissioning, servicing, or altering the system in the future. Use of the software by individuals under contract to the Owner shall be restricted to use on the owner's computers and only for the purpose of commissioning, servicing, or altering the installed system.

4. All project developed software, files and documentation shall become the property of the Owner. These include but are not limited to:

    4.1. Server and Workstation software.

    4.2. Application Programming Tools.

    4.3. Configuration Tools.

    4.4. Addressing Tools.

    4.5. Application Files.

    4.6. Configuration Files.

    4.7. Graphic Files.

    4.8. Report Files.

    4.9. Graphic Symbol Libraries.

    4.10. All Documentation.

25 00 07. MANUFACTURERS

1. Manufacturers with server software that currently resides on the University of Minnesota network and that meet all requirements defined in this BAS Control Standard.

2. Controllers that meet BACnet conformance listed in appendix A which include specific BACnet object, property, and services requirements.

3. Control Contractors shall provide all the "Requirements for use at University of Minnesota Buildings" from Appendix A for their approved controllers.

4. Approved Manufacturers that don't currently have virtualized Web Server supervisor software on the University of Minnesota network must include the cost of furnishing and installing Web Server supervisor software in their proposed cost. All University of Minnesota network security, software license and installation requirements shall apply to the Web Server software. Web servers must meet the minimum web services requirements as outlined in Appendix A.

5. Approved BAS Installation Contractors

    5.1. Johnson Controls – 2605 Fernbrook Lane North, Suite T, Plymouth, MN 55447

    5.2. Siemens – 5939 Rice Creek Parkway Shoreview MN 55126

25 00 08. SYSTEM ARCHITECTURE

1. The DDC system architecture shall consist of three layers: the IP layer devices, the Building Level Net devices and Web services devices.

2. All new building controllers, PCs and IP devices shall be connected to the University of Minnesota LAN. The LAN connection shall be coordinated with University of Minnesota IT personnel. The Temperature Control Contractor shall be responsible for all inner building cat 6 wiring. University of Minnesota IT department will provide a single RJ-45 Ethernet connection point in the building. All internal building communications wires including managed switches shall be supplied and installed by the Temperature Control Contractor. Cimetrics router B3075 must be used in buildings requiring IP drops of more than 10 for all devices that communicate exclusively BACnet/IP.

3. BACnet Building Controllers (B-BC) shall be used to connect each Building Level Net to the IP layer.

25 00 09. NETWORKING

1. IP Network: All devices that connect to the U of M LAN shall be capable of operating at 1 GB per second or higher.

2. IP-to-Building Level Net Routing Devices.

    2.1. BACnet Building Controller (Supervisory Controller) shall be used to provide this functionality.

    2.2. These devices shall be configurable locally with EIA-232, IP connection or USB communications.

2.3. The routing configuration shall be such that only data packets from the Building Level Net devices that need to travel over the IP level of the architecture are forwarded. Additionally, data packets from the IP level that need to travel to the sub-LAN devices will be forwarded. BACnet 'Who is' and 'Who has' global and local broadcast messages should be answered by the supervisory controller as a proxy whenever possible. It is the intention of the U of M to minimize network traffic between supervisory controllers and Building Level Net devices using BACnet MS/TP protocol. BACnet I-Am messages must be set to Unicast. Locally or globally broadcast UDP I-Am messages are forbidden on the U of M LAN.

3. Building Level Net

3.1. The wiring of components shall use a bus, ring or daisy chain concept with no tees, stubs, or free topology. Building Level Net device programming must be accessible via pass through from supervisory controller. Disconnecting Building Level Net for the purpose of programming sub controllers is prohibited.

4. Repeaters

4.1. EIA 485 repeaters are prohibited. If additional BACnet routing is needed due to distance in excess of 4000 feet or number of BACnet MS/TP devices exceeds 60 on one LAN, the U of M accepts the use of BACnet BASRTLXB Contemporary Controls Routers or equivalent. BASRT-B Contemporary Controls routers are prohibited. The U of M prohibits more than 60 BACnet MS/TP devices on one network.

25 00 010. BUILDING LEVEL CONTROLLERS (B-BC)

1. Building level DDC controllers shall be microprocessor-based, multi-tasking, multi-user, real-time digital control processors fully capable of being integrated with other BACnet building controllers or BACnet operator workstations.

2. Building level DDC controllers shall utilize BACnet open standard communication protocol. All Supervisory controllers shall communicate using BACnet/IP.

3. A BACnet Building Controller (B-BC) as defined by ASHRAE Annex L is a general purpose, field programmable device capable of carrying out a variety of building automation and control tasks. The BACnet Building Controller enables the specification of the following:

3.1. Data Sharing

1A. Ability to provide the values of any of its BACnet objects.

1B. Ability to retrieve the values of BACnet objects from other devices.

1C. Ability to allow modifications such as scheduling and present value of some or all its BACnet objects by another device.

3.2. Alarm and Event Management

2A. Generation of alarms / events notifications and the ability to direct them to recipients using the BACnet intrinsic or algorithmic alarming method in a message confirmed format.

2B. Maintain a list of unacknowledged alarms / events retrievable using standard BACnet Services.

2C. Maintain a list of alarms / events retrievable using standard BACnet Services.

2D. Notifying other recipients that the acknowledgment has been received.

2E. Adjustment of alarm / event parameters.

3.3. Scheduling

3A. Ability to schedule/modify weekly and exception schedule output actions, both in the local device and in other devices, both binary and analog, based on date and time.

3.4. Trending

4A. Collection and delivery of (time, value) pairs which includes a complete 'BACnet trend log buffer upload' using full BACnet segmentation.

3.5. Device and Network Management

5A. Ability to respond to information about its status.

5B. Ability to respond to requests for information about any of its objects.

5C. Ability to respond to communication control messages.

5D. Ability to synchronize its internal clock upon request using BACnet time sync services.

5E. Ability to perform re-initialize upon request.

5F. Ability to upload its configuration and allow it to be subsequently restored.

5G. Ability to command half routers to establish and terminate connections.

3.6. If Building Controllers have embedded I/O, all the requirements for I/O that are described under Unit Level Controllers shall apply.

3.7. All ANSI/ASHRAE 135-2012 BACnet objects and object properties shall be supported so that alarms are sent from the Temperature Control Contractor's BACnet device without having to be solicited from any University of Minnesota BACnet Operators Workstation (BOWS) or Web Server.

3.8. DDC panels and devices must utilize ANSI/ASHRAE 135-2012 or newer BACnet Communications Protocol on a single building level network. BACnet communications must not cause derogated communications on the site's existing temperature control network including the site IP LAN. Derogation includes router, switch, or hub lockups, BACnet building controller lockups, excessive site network slowdowns, broadcast storms, unnecessary and repeated network broadcasts including BACnet 'who is', 'who has', I am, I have, and 'who is router' messages. Who is, I am messages should be limited to initially determine BACnet MAC addresses, segmentation support, IPs and maximum APDU length. Other reasons include when a device moves. I am messages must be unicast. BACnet MS/TP devices may not exceed 60 on a single BACnet MS/TP network. Should additional routers be deemed necessary, BACnet BASRTLXB Contemporary Controls Routers or equivalent can be used. BASRT-B Contemporary Controls routers are prohibited.

3.9. All building level controllers shall have a local port that can connect to a laptop PC or other hand-held tool for local service work, troubleshooting, etc. Acceptable methods of connection are USB, Ethernet, and EIA-485.

3.10. Memory: Each DDC controller shall have sufficient memory to support its own operating system and data bases including continuous trending on all physical analog points for that controller (AV, AI, AO) based on 700 sample intervals. DDC and supervisory controllers must not exceed 80 memory loads for both volatile and nonvolatile memory.

3.11. Integrated On-line Diagnostics: Each DDC controller shall continuously perform self-diagnostics and communication diagnosis of all associated unit level equipment. The DDC controller shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each DDC controller and shall not require the connection of an auxiliary I/O device.

11A. The system is to report the alarm at the workstations and/or Web Server. In addition, the alarm will go to the building engineer, and building manager via email.

3.12. Power Fail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all DDC controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of seventy-two (72) hours. Upon restoration of normal power, the DDC controller shall automatically resume full operation without manual intervention. Should a DDC controller memory be lost for any reason, the user shall have the

capability of reloading the DDC controller via the local area network or via the local interface port.

3.13. System architectural design shall eliminate dependence upon any single device, front-end or higher level of controller for alarm reporting and control execution. Each DDC controller shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not majorly interrupt the execution of control strategies at other operational devices. All bound objects between controllers must maintain the last value or go to a pre specified relinquish default.

25 00 011. UNIT LEVEL CONTROLLERS

1. Each Unit Level DDC controller shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, input, and output (DI, DO, AI, AO) capabilities. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification, the project drawings, and the point lists.

2. Unit level DDC controllers shall utilize BACnet/MSTP open standard communication protocol. BACnet arc net is not acceptable.

3. Power Fail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all DDC controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of seventy-two (72) hours. Upon restoration of normal power, the DDC controller shall automatically resume full operation without manual intervention. Should a DDC controller memory be lost for any reason, the user shall have the capability of reloading the DDC controller via the local area network or via the local interface port.

4. Each controller will be programmed such that each controlled device will have a default value in which to be commanded to in the event of a control sensor failure. The acceptable default values are, last command, full open, or full closed.

5. Controller I/O Requirements

    5.1. Analog Input Circuits

        1A. For non-linear sensors such as thermistors and flow sensors the controller shall provide software support for the linearization of the input signal.

    5.2. Binary Input Circuits

        2A. Dry contact sensors shall wire to the controller with two wires.

2B. An external power supply in the sensor circuit shall not be required.

5.3. Pulse Input Circuits

3A. Pulse input sensors shall wire to the controller with two wires.

3B. An external power supply in the sensor circuit shall not be required.

3C. The pulse input circuit shall be able to process up to 20 pulses per second.

5.4. True Analog Output Circuits

4A. The logical commands shall be processed by a digital to analog (D/A) converter chip. The 0% to 100% control signal shall be scalable to the full output range which shall be either 0 to 10 VDC, 4 to 20 milliamps or 0 to 20 milliamps or to ranges within the full output range.

4B. The resolution of the D/A chip shall not be less than 0.04 Volts per increment or 0.08 milliamps per increment.

5.5. Binary Output Circuits

5A. Single pole, single throw or single pole, double throw relays.

5B. Voltage sourcing or externally powered triacs with support for up to 30 VAC and 0.5 amps at 24 VAC.

5.6. Program Execution

6A. Process control loops shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.

6B. The sample rate for a process control loop shall be adjustable and shall support a maximum sample rate of 1 second.

6C. The sample rate for process variables shall be adjustable and shall support a maximum sample rate of 1 second.

6D. The sample rate for algorithm updates shall be adjustable and shall support a maximum sample rate of 1 second.

6E. The application shall have the ability to determine if a power cycle to the controller has occurred and the application programmer shall be able to use the indication of a power cycle to modify the sequence of controller immediately following a power cycle.

6. Unit level controllers shall not be dependent upon any other controller (unit or building level) to maintain safe operation of the controlled equipment.

7. All unit level controllers and/or enclosures shall be clearly labeled with their Node address. Tag all wiring on the DDC side of the interface panel identifying the associated point.

8. **PROHIBITED:** The combination of master/slave panels or point expansion for PID control loops without prior approval from Owner.

9. **PROHIBITED:** Splitting mechanical systems between more than one Unit Level controller without prior approval from Owner.

25 00 012. OPERATOR WORKSTATION (OWS)

1. The Operator Interface Workstations for those vendors that still use them will comprise a Personal Computer (PC) together with operator terminals. The PC shall be a fully integrated node on the management level network and shall provide the operator with a graphical interface into the entire network. The monitoring and control functions of the BAS shall be totally independent of the PC such that if the PC is not operational there shall be no impact on the building control systems except for the reduced operator interface capability at that location.

2. On a project where an OWS is specified, University of Minnesota will furnish and install any required PCs for the OWS at the project location. The contractor shall furnish and install all software and tools.

25 00 013. DDC SYSTEM SOFTWARE

1. Web-based BAS Server Software

    1.1. Utilize the existing web-based BAS server software for user access via industry standard web browsers using absolutely no add ons. The contractor shall furnish controllers that are compatible with the current version of BAS server software.

    1.2. BAS controllers or software that requires proprietary dongles, hardware add-on's, cables, etc. to adjust control logic or modify programming and graphics is not acceptable. BAS controllers must be able to be programmed through the BAS server software and/or with a standard Windows 10 or later PC laptop.

    1.3. The contractor shall furnish and install a temporary server-workstation with BAS server software in the building until virtual server software is accessible on the University of Minnesota network. The temporary server shall not be connected to the University of Minnesota network.

    1.4. Contractor shall provide all materials and labor required to connect to the BAS server software and to provide user access via industry standard web browsers which include Microsoft Edge, Google Chrome and Firefox.

2. Software Upgrades

    2.1. The contractor shall furnish and install the most current version of all BAS software available throughout the warranty period.

2.2. It is University of Minnesota Facility Services desire to install the most current hardware and software available without jeopardizing control integration conformance or University of Minnesota Standards.

2.3. The contractor shall provide current BACnet Interoperability Building Blocks (BIBBs) and PICs Statements with a written request to approve the installation of new firmware. The newest firmware must be BTL listed.

3. BACnet Operator Workstations (OWS)

3.1. Hardware Communication Function

1A. The OWS shall extract data from the hardware environment and move the data to the data server and/or present the data to the presentation system.

1B. The OWS shall extract data from the data server and present the data to the data presentation system.

1C. The OWS shall track operator actions at the presentation system and write a record of activities to the data server.

3.2. BACnet Compliance

2A. The OWS shall be able to initiate a “Who Is” request to the network.

2B. The OWS shall respond to a “Who Is” request from another BACnet device with an “I Am” response which must be unicast.

2C. The OWS shall be able to read binary and analog data from BACnet devices that support the reading of data.

2D. The OWS shall be able to write binary and analog data to BACnet devices that support the writing of data from a BACnet OWS.

2E. The OWS shall be able to receive alarm messages from BACnet devices that export alarm messages.

2F. The OWS shall be able to acknowledge alarms from BACnet devices.

2G. The OWS shall be able to edit time schedule parameters in BACnet devices that support the editing of time schedule parameters from a BACnet OWS.

2H. The OWS shall be able to retrieve a collection of trend samples from a BACnet device that stores the data and permits the export of that data to a BACnet OWS.

2I. The OWS shall be able to initiate time synchronization commands to all BACnet devices that support the receipt of time synchronization commands from a BACnet OWS.

25 00 014. NETWORK COMMUNICATION TRUNK AND TERMINATIONS

1. A backbone communication tie in point will be provided and installed by University of Minnesota IT. The Temperature Controls Contractor is responsible for all DDC network wiring within the building.

2. The Temperature Controls Contractor shall provide a network riser for all locations as part of construction, submittals, and as-built documents. All fiber and network devices shall be clearly marked.

25 00 015. IP INTERFACE DEVICES

1. Install Building Controllers for each required connection to the dedicated DDC IP network.

2. The Building Controllers shall be configured and commissioned to ensure that the only data traffic on the IP is data that is essential for operation of the system.

25 00 016. SYSTEMS INTEGRATION

1. The Temperature Controls Contractor shall be fully responsible for the installation and commissioning of the integrated system.

2. The Temperature Controls Contractor shall be responsible for all on-site and off-site programming as required to provide a fully operational integrated system. Contractor shall coordinate all programming and point mapping requirements with University of Minnesota Facility Services. If the Contractor deems changes to the Contract Documents necessary, submit details in writing, to the Owner for approval.

3. The Temperature Controls Contractor shall provide all engineering and analysis work necessary to determine the method of network connectivity. The Contractor shall furnish, install and program hardware, wiring, network devices, cabling, software and graphics to connect the new DDC controls system to University of Minnesota network.

25 00 017. BUILDING SYSTEMS AUTOMATION NETWORK PERFORMANCE

1. The Temperature Controls Contractor will supply all hardware software labor, material, and expertise necessary to tie the BACnet building controller(s) to the University of Minnesota network. BACnet integration must conform to Data Link Layer Option BACnet /IP shown in BACnet ANSI/ASHRAE 135-2012 publication Annex J.

2. All BACnet read property requests from any BACnet Operator Workstation must not take more than 20ms to process once the BACnet Building Controller receives the read request. Object properties that are read requested that require multiple segmented packets must not take more than 50ms to process the request. All information that is received from a read property multiple or single read property must not be older than 10 seconds.

25 00 018. BUILDING ALARMS AND CRITICAL SYSTEM MONITORING

1. The control specifications and/or point lists shall identify building alarm requirements.

2. The Temperature Control Contractor shall provide an alarm matrix with the Control Submittal that lists all building alarm points. The matrix shall identify an alarm class for each alarm point. Alarm Classes shall include:

3. Critical Alarms: Refer to Appendix B.

4. Page/Text Alarms: Building alarms that need immediate attention but are not critical. Alarm notification to the Building Engineer by page, text or by a means of communication defined by the Building Manager.

5. General Alarms: All building alarms. Alarm notification to BAS.

6. The Temperature Control Contractor shall use the University of Minnesota Critical Alarm Standard in Appendix B as a guide for defining critical alarms.

7. The University of Minnesota Building Manager, Building Engineer and Automation Technician shall review the building alarm matrix and make corrections as needed. The Approved Alarm Matrix will be returned to the Temperature Control Contractor and shall be used for programming building alarms.

8. The Temperature Control Contractor shall follow the BACnet Alarm Recipient Standard in Appendix D.

9. In facilities where critical system monitoring is performed by DDC equipment, the controls contractor shall be responsible for all required material and labor to connect the Owner's critical equipment to the DDC system.

10. In buildings with emergency generators, all DDC devices and networking equipment that monitor and/or transmit critical system monitoring points shall be connected to emergency power.

11. The controls contractor shall provide UPS power supplies for all DDC and networking devices that monitor and/or transmit critical system monitoring points. UPS shall be capable of maintaining full operation for a period of no less than 4 hours.

12. The DDC system shall monitor all UPS required under this section and report an alarm to PSECC whenever the UPS senses a loss of primary power or indicates a fault of any kind.

25 00 019. POINT NAMING/POINT LOGICAL GROUPING AND GRAPHICS

1. The programmer shall meet with University of Minnesota Facility Services before proceeding with programming to review point naming, system layout, point logical grouping, graphics, graphical display response time, and tree structure. The controls contractor shall contact University of Minnesota Automation Group before deviating from University of Minnesota Standards. Failure to work within University of Minnesota Standards may result in the Contractor being required to redo their work without compensation.

2. Supervisory controllers must be named with their corresponding building number & panel number. Before database generation is started, controls contractors are advised to contact the University of Minnesota for questions regarding naming. University of Minnesota reserves the right to require changes to point naming if the controls contractor does not clarify naming before start of the controller database(s).

3. BACnet Object Identification numbers must also include building number and panel number. Controls contractors must coordinate Device IDs & IP address information with University of Minnesota prior to the start of database generation.

4. The Temperature Control Contractor shall follow the BACnet Device and Network Number Standards in Appendix C for all University of Minnesota controls projects.

25 00 020. PROGRAMMING METHODS USING THE GRAPHIC INTERFACE

1. Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user's application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to other objects on other pages for easy identification. Links will vary in color depending on the type of link, i.e., internal, external, hardware, etc.

2. Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons including use of ladder-logic and function-block with connector type programming logic. Use of BASIC, Visual BASIC, C++, custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.

3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When Off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.

4. Control system logic shall be viewable in real time from the Web Browser. Linking real time control system logic from the server to the Web Browser in a "view only" mode is acceptable.

5. Control PIDs shall be accessible in real time for tuning and diagnosing from the Web Browser. Exposing adjustable PID's in Web Browser graphics is acceptable.

6. All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database objects shall not be allowed.

7. The system shall support object duplication within a customer's database. An application, once configured, can be copied, and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

8. The O&M Documents and sequence of operation shall be viewable from the control system.

9. University of Minnesota will not alter any programming or graphics until after the warranty period is complete without the permission of the control's contractor.

25 00 021. CRITICAL ALARM COMMISSIONING

1. Complete the Critical Alarm Commissioning Checklist defined in Appendix E and include it with close-out documentation.

2. Schedule a critical alarm commissioning test with the Owner to test critical BACnet intrinsic and algorithmic alarms going to the University of Minnesota PSECC (PSECC) BACnet to ANSI/SIA DC-09-2013: Security Industry AsPSECCiation Manitou Interface. The Control Contractor shall test each critical BACnet alarm to confirm that they are properly transmitted to the PSECC interface as outlined in the control and integration specification.

25 00 022. COMMISSIONING

1. Temperature controls contactor shall perform services and activities to participate in the commissioning. Provide web-based access to the commissioning agent as required to facilitate commissioning. Fill out forms and provide information as required to participate in the project commissioning. This may include operation of ventilation systems, valves, and other equipment as directed by and in the presence of the Commissioning Agent. Commissioning Agent shall review the performance reports, forms, and controls submitted by the temperature controls contactor. The temperature controls contactor shall work with the Commissioning Agent to rectify issues identified in the reports and in the project commissioning.

2. Complete the commissioning checklist defined in Appendix F. The Commissioning Agent in coordination with the Controls Contractor shall complete and sign off on all checklist tasks prior to the start of system warranty. The Commissioning Agent and Controls Contractor shall arrange a review meeting with the Owner to demonstrate that all of the commissioning checklist tasks have been completed to the satisfaction of the Owner. The completed commissioning checklist form containing sign-off from all parties shall be included in the close-out documentation submitted by the Contractor.

APPENDIX A: BACNET OBJECT, PROPERTIES AND SERVICES / WEB SERVICES COMPLIANCE STANDARD

University of Minnesota requires HTML5 web browser access and specific BACnet compliance to all University of Minnesota Building Automation Systems (BAS). Web Access and as defined in this Appendix must be accomplished using standard web browsers utilizing HTML5 without the additions of any web browser add-ons, extension or plugins. HTML5 is the latest "standardized" implementation of HTML, CSS, and JavaScript. University of Minnesota shall utilize Chrome, Firefox or Microsoft Edge web browsers for DDC installations. This same level of access must be available using smart devices, tablets and iPads. The Web Browser user interface shall (as a minimum) provide navigation, and display of animated graphics, schedules, alarms/events, live graphic programs, active graphic setpoint controls, configuration menus for operator access, reports, and reporting actions for events and schedules. University of Minnesota requires access to DDC systems based on the minimum requirements shown below and requires the ability to navigate through the system using a web browser to accomplish these requirements.

1. Data Sharing
    a. Ability to read all required properties of BACnet objects as defined in APPENDIX A.
    b. Ability to modify BACnet properties as defined in APPENDIX A. All objects listed as writable in APPENDIX A must also be writable using Web Client.
    c. The ability to control binary, analog and multistate (if existing) present values via Web Client.
    d. The ability to read and write to all properties including setpoint adjustments as defined in APPENDIX A based on BACnet 2012 standard (or newer).
2. Alarm and Event Management
    a. Ability to receive and process alarms via Web Client.
    b. Retrieve a list of unacknowledged alarms / events to a standard web report.
    c. Retrieve a list of alarms / events retrievable using a standard web report.
    d. Notify other BACnet recipients that the acknowledgment has been performed.
    e. Perform adjustment of alarm / event parameters.
3. Scheduling
    a. Ability for Web Client to schedule/modify weekly and exception schedule output actions, both in the local device and in other devices based on controller date and time. Ability to read and write schedule properties as defined in APPENDIX A.
4. Trending
    a. Use Web Client to setup the collection of (time, value) pairs which includes a complete ‘trend log buffer upload’ using standard BACnet trend harvesting techniques.
    b. Ability to display and print trend information from Web Client using ‘trend log buffer’ with the ability to display trend data in both text and graphical format.
    c. Long term harvested trends must be accessible for text and graphical display from Web Client. This data is typically present at the vendor’s server and not a supervisory controller.
5. Graphic Display

a. Ensure that vender developed Web Client based graphics can be displayed 'as is' on web server or displayed with no loss of usage after a graphic conversion has been applied. All graphics that have been developed for vendor's thick client must be hostable without having to rebuild or redesign graphical screens in order to host and access them from a thin client Web Client. Graphics must also be accessible from Smart Devices, Tablets and IPads browsers.

b. Navigation through the Web Client GUI shall be accomplished by clicking on appropriate level of a navigation tree (consisting of expandable and collapsible tree control), and/or by selecting dynamic links to other system graphics. Both the navigation tree and graphics screen shall be displayed simultaneously, enabling the operator to select a specific system or equipment, and view the corresponding graphic. The navigation tree if present must show a physical tree layout based on individual panel configurations and a custom tree layout typically based on fans, rooms, cooling and heating systems etc.

6. User Configuration

   a. Web Client must have the ability to create and modify users for system access.

Standard Object Types Supported:

Owner requires support for the following Standard ANSI/ASHRAE 135-2012 (or newer). BACnet objects to be exposed using BACnet and web services and accessible using HTML5 based browser as described in the beginning of this Appendix. See the Object tables below for Individual Object Property requirements.

BACnet Object Type to be exposed as web service	**University of Minnesota Requirement for each object**
Analog Input	**Vendor required to support object**
Analog Output	**Vendor required to support object**
Analog Value	**Vendor required to support object if object is used**
Binary Input	**Vendor required to support object**
Binary Output	**Vendor required to support object**
Binary Value	**Vendor required to support object if object is used**
Calendar	**Vendor required to support object**
Device	**Vendor required to support object**
Event Enrollment	**Vendor required to support object if intrinsic alarming is not supported**
Multistate Input	**Vendor required to support object if object is used**
Multistate Output	**Vendor required to support object if object is used**
Multistate Value	**Vendor required to support object if object is used**
Notification Class	**Vendor required to support object**
Schedule	**Vendor required to support object**
Trend Log	**Vendor required to support object**

University of Minnesota requires access to all BACnet Objects and properties using HTML5 web access as shown in Web requirements column. Column descriptions shown as **R** are required to be readable. Columns that show **O** are optional meaning University of Minnesota does not require this property but may give a higher preference to vendors that support these optional properties. Columns that show **W** are required to be writable by University of Minnesota. Properties that indicate **Not Required** are not required by the U of M and do not give higher preference.

Analog Input	BACnet 2012 Requirements	University of Minnesota BACnet Requirements	University of Minnesota Web Requirements
Object_Identifier	R	R	R
Object_Name	R	R	R
Object_Type	R	R	R
Present_Value	R1	R1	R1
Description	O	O	O
Device_Type	O	O	O
Status_Flags	R	R	R
Event_State	R	R	R
Reliability	O	O	O
Out_Of Service	R	R	R
Update_Interval	O	O	O
Units	R	R	R
MinPresValue	O	O	O
Max_Pres_Value	O	O	O
Resolution	O	O	O
COV_Increment	O2	O2	O2
Time Delay	O3,5	O3,5	O3,5
Notification_Class	O3,5	O3,5	O3,5
High_Limit	O3,5	O3,5	O3,5
Low_Limit	O3,5	O3,5	O3,5
Deadband	O3,5	O3,5	O3,5
Limit_Enable	O3,5	O3,5	O3,5
Event_Enable	O3,5	O3,5	O3,5
Acked_Transitions	O3,5	O3,5	O3,5
Notify_Type	O3,5	O3,5	O3,5
Event_Time_Stamps	O3,5	O3,5	O3,5
Event_Message_Texts	O4,5	O4,5	O4,5
Event_Message_Texts_Con fig	O5	O5	O5
Event_Detection_Enable	O3,5	O3,5	O3,5
Event_Algorithm_Inhibit_Ref	O5	O5	O5
Event_Algorithm_Inhibit	O5,6	O5,6	O5,6
Time_Delay_Normal	O5	O5	O5
Reliability_Evaluation_Inhibit	O7	O7	O7
Property_List	R	R	R
Profile Name	O	Not Required	Not Required

1 This property is required to b writable when Out_Of_Service is TRUE.
2 This property is required if, and shall be present only if, the object supports COV reporting.
3 These properties are required if the object supports intrinsic reporting**. University of Minnesota requires intrinsic alarming or algorithmic.**
4 This property, if present, is required to be read-only.
5 These properties shall be present only if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
6 Event_Algorithm_Ingibit shall be present if Event_Algorithm_Inhibit_Ref is present.
7 If this property is present, then the Reliability property shall be present.

Analog Output Property	BACnet 2012 Requirements	University of Minnesota Requirements	University of Minnesota Web Requirements
Object_Identifier	R	R	R
Object_Name	R	R	R
Object_Type	R	R	R
Present_Value	W	W	W
Description	O	O	O
Device_Type	O	O	O
Status_Flags	R	R	R
Event_State	R	R	R
Reliability	O	O	O
Out_Of Service	R	R	R
Units	R	R	R
Min_Pres_Value	O	O	O
Max_Pres_Value	O	O	O
Resolution	O	O	O
Priority_Array	R	R	R
Relinquish_Default	R	R	R
COV_Increment	O1	O1	O1
Time Delay	O2,4	O2,4	O2,4
Notification_Class	O2,4	O2,4	O2,4
High_Limit	O2,4	O2,4	O2,4
Low_Lim it	O2,4	O2,4	O2,4
Deadband	O2,4	O2,4	O2,4
Limit_Enable	O2,4	O2,4	O2,4
Event_Enable	O2,4	O2,4	O2,4
Acked_Transitions	O2,4	O2,4	O2,4
Notify_Type	O2,4	O2,4	O2,4
Event_Time_Stamps	O2,4	O2,4	O2,4
Event_Message_Texts	O3,4	O3,4	O3,4
Event_Message_Texts_Config	O4	O4	O4
Event_Detection_Enable	O2,4	O2,4	O2,4
Event_Algorithm_Inhibit_Ref	O4	O4	O4
Event_Algorithm_Inhibit	O4,5	O4,5	O4,5
Time_Delay_Normal	O4	O4	O4
Reliability_Evaluation_Inhibit	O6	O6	O6
Property_List	R	R	R
Profile_Name	O	Not Required	Not Required

1 This property is required if, and shall be present only if, the object supports COV reporting.
2 These properties are required if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
3 This property, if present, is required to be read-only.
4 These properties shall be present only if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
5 Event_Algorithm_Inhibit shall be present if Event_Algorithm_Inhibit_Ref is present.
6 If this property is present, then the Reliability property shall be present.

Analog Value Property	BACnet 2012 Requirements	University of Minnesota Requirements	University of Minnesota Web Requirements
Object_Identifier	R	R	R
Object_Name	R	R	R
Object_Type	R	R	R
Present_Value	R4	R4	R4
Description	O	O	O
Status_Flags	R	R	R
Event_State	R	R	R
Reliability	O	O	O
Out_Of Service	R	R	R
Units	R	R	R
Priority_Array	O1	O1	O1
Relinquish_Default	O1	O1	O1
COV_Increment	O2	O2	O2
Time Delay	O3,6	O3,6	O3,6
Notification_Class	O3,6	O3,6	O3,6
High_Limit	O3,6	O3,6	O3,6
Low_Limit	O3,6	O3,6	O3,6
Deadband	O3,6	O3,6	O3,6
Limit_Enable	O3,6	O3,6	O3,6
Event_Enable	O3,6	O3,6	O3,6
Acked_Transitions	O3,6	O3,6	O3,6
Notify_Type	O3,6	O3,6	O3,6
Event_Time_Stamps	O3,6	O3,6	O3,6
Event_Message_Texts	O5,6	O5,6	O5,6
Event_Message_Texts_Config	O6	O6	O6
Event_Detection_Enable	O3,6	O3,6	O3,6
Event_Algorithm_Inhibit_Ref	O6	O6	O6
Event_Algorithm_Inhibit	O6,7	O6,7	O6,7
Time_Delay_Normal	O6	O6	O6
Reliability_Evaluation_Inhibit	O8	O8	O8
MinPres_Value	O	O	O
Max Pres Value	O	O	O
Resolution	O	O	O
Property_List	R	R	R
Profile Name	O	Not Required	Not Required

1 These properties are required if, and shall be present only if, Present_Value is commandable.
2 This property is required if, and shall be present only if, the object supports COV reporting.
3 These properties are required if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
4 If Present_Value is commandable, then it is required to be writable. This property is required to be writable when Out_Of_Service is TRUE.
5 This property, if present, is required to be read-only.
6 These properties shall be present only if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
7 Event_Algorithm_Inhibit shall be present if Event_Algorithm_Inhibit_Ref is present.
8 If this property is present, then the Reliability property shall be present.

Binary Input Property	BACnet 2012 Requirements	University of Minnesota Requirements	University of Minnesota Web Requirements
Object_Identifier	R	R	R
Object_Name	R	R	R
Object_Type	R	R	R
Present_Value	R1	R1	R1
Description	O	O	O
Device_Type	O	O	O
Status_Flags	R	R	R
Event_State	R	R	R
Reliability	O	O	O
Out_Of Service	R	R	R
Polarity	R	R	R
Inactive:Text	O2	O2	O2
Active_Text	O2	O2	O2
Change_Of State_Time	O3	O3	O3
Change_Of State_Count	O3	O3	O3
Time_Of_State_Count_Reset	O3	O3	O3
Elapsed_Active_Time	O4	O4	O4
Time_Of Active_Time_Reset	O4	O4	O4
Time Delay	O5,7	O5,7	O5,7
Notification_Class	O5,7	O5,7	O5,7
Alarm_Value	O5,7	O5,7	O5,7
Event_Enable	O5,7	O5,7	O5,7
Acked_Transitions	O5,7	O5,7	O5,7
Notify_Type	O5,7	O5,7	O5,7
Event_Time_Stamps	O5,7	O5,7	O5,7
Event_Message_Texts	O6,7	O6,7	O6,7
Event_Message_Texts_Config	O7	O7	O7
Event_Detection_Enable	O5,7	O5,7	O5,7
Event_Algorithm_Inhibit_Ref	O7	O7	O7
Event_Algorithm_Inhibit	O7,8	O7,8	O7,8
Time_Delay_Normal	O7	O7	O7
Reliability_Evaluation_Inhibit	O9	O9	O9
Property_List	R	R	R
Profile Name	O	Not Required	Not Required

1 This property is required to be writable when Out_Of_Service is TRUE.
2 If one of the optional properties Inactive_Text or Active_Text is present, then both of these properties shall be present.
3 If one of the optional properties Change_Of_State_Time, Change_Of_State_Count, or Time_Of_State_Count_Reset is present, then all of these properties shall be present.
4 If one of the optional properties Elapsed_Active_Time or Time_Of_Active_Time_Reset is present, then both of these properties shall be present.
5 These properties are required if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
6 This property, if present, is required to be read-only.
7 These properties shall be present only f the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
8 Event_Algorithm_Inhibit shall be present if Event_Algorithm_Ingibit_Ref is present.

9 If this property is present, then the Reliability property shall be present.

Binary Output Property	BACnet 2012 Requirements	University of Minnesota Requirements	University of Minnesota Web Requirements
Object_Identifier	R	R	R
Object_Name	R	R	R
Object_Type	R	R	R
Present_Value	W	W	W
Description	O	O	O
Device_Type	O	O	O
Status_Flags	R	R	R
Event_State	R	R	R
Reliability	O	O	O
Out_Of Service	R	R	R
Polarity	R	R	R
Inactive_Text	O1	O1	O1
Active_Text	O1	O1	O1
Change_Of State_Time	O2	O2	O2
Change_Of State_Count	O2	O2	O2
Time_Of State_Count_Reset	O2	O2	O2
Elapsed_Active_Time	O3	O3	O3
Time_Of ActiveTime_Reset	O3	O3	O3
Minimum_Off Time	O	O	O
Minimum_On_Time	O	O	O
Priority_Array	R	R	R
Relinquish_Default	R	R	R
Time Delay	O4,6	O4,6	O4,6
Notification_Class	O4,6	O4,6	O4,6
Feedback_Value	O4	O4	O4
Event_Enable	O4,6	O4,6	O4,6
Acked_Transitions	O4,6	O4,6	O4,6
Notify_Type	O4,6	O4,6	O4,6
Event_Time_Stamps	O4,6	O4,6	O4,6
Event_Message_Texts	O5,6	O5,6	O5,6
Event_Message_Texts_Config	O6	O6	O6
Event_Detection_Enable	O4,6	O4,6	O4,6
Event_Algorithminhibit_Ref	O6	O6	O6
Event_Algorithm_Inhibit	O6,7	O6,7	O6,7
Time_Delay_Normal	O6	O6	O6
Reliability Evaluation Inhibit	O8	O8	O8
Property_List	R	R	R
Profile_Name	O	Not Required	Not Required

1 If one of the optional properties Inactive_Text or Active_Text is present, then both of these properties shall be present.
2 If one of the optional properties Change_of_State_Time, Change_Of_State_Count, or Time_Of_State_Count_Reset is present, then all of these properties shall be present.
3 If one of the optional properties Elapsed_Acive_Time_ or Time_Of_Active_Time_Reset is present, then both of these properties shall be present.
4 These properties are required if the object supports intrinsic reporting. **The University of Minnesota requires intrinsic alarming or algorithmic.**

5 This property, if present, is required to be read-only.
6 These properties shall be present only if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
7 Event_Algorithm_Inhibit shall be present if Event_Algorithm_Inhibit_Ref is present
8 If this property is present, then the Reliability property shall be present.

Binary Value Property	**BACnet 2012 Requirements**	**University of Minnesota Requirements**	**University of Minnesota Web Requirements**
Object_Identifier	R	R	R
Object_Name	R	R	R
Object_Type	R	R	R
Present_Value	R1	R1	R1
Description	O	O	O
Status_Flags	R	R	R
Event_State	R	R	R
Reliability	O	O	O
Out_Of Service	R	R	R
Inactive_Text	O2	O2	O2
Active_Text	O2	O2	O2
Change_Of State_Time	O3	O3	O3
Change_Of State_Count	O3	O3	O3
Time_Of State_Count_Reset	O3	O3	O3
Elapsed_Active_Time	O4	O4	O4
Time_Of Active_Time_Reset	O4	O4	O4
Minimum_ Off_ Time	O	O	O
Minimum_On_Time	O	O	O
Priority_Array	O5	O5	O5
Relinquish_Default	O5	O5	O5
Time Delay	O6,8	O6,8	O6,8
Notification_ Class	O6,8	O6,8	O6,8
Alarm_Value	O6,8	O6,8	O6,8
Event_Enable	O6,8	O6,8	O6,8
Acked_Transitions	O6,8	O6,8	O6,8
Notify_Type	O6,8	O6,8	O6,8
Event_Time_Stamps	O6,8	O6,8	O6,8
Event_Message_Texts	O7,8	O7,8	O7,8
Event_Message_Texts_Config	O8	O8	O8
Event_Detection_Enable	O6,8	O6,8	O6,8
Event_Algorithm_Inhibit_Ref	O8	O8	O8
Event_Algorithm_Inhibit	O8,9	O8,9	O8,9
Time_Delay_Normal	O8	O8	O8
Reliability_Evaluation_Inhibit	O10	O10	O10
Property_List	R	R	R
Profile Name	O	Not Required	Not Required

1 If Present_Value is commandable, then it is required to be writable. This property is required to be writable when Out_Of_Service is TRUE.
2 If one of the optional properties Inactive_Text or Active_Text is present, then both of these properties shall be present.

3 If one of the optional properties Change_Of_State_Time, Change_Of_State_Count, or Time_Of_State_Count_Reset is present, then all of these properties shall be present.
4 if one of the optional properties Elapsed_Active_Time or Time_Of_Active_Time_Reset is present, then both of these properties shall be present.
5 These properties are required if, and shall be present only if, Present_Value is commandable.
6 These properties are required if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
7 This property, if present, is required to be read-only.
8 These properties shall be present only if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
9 Event_Algorithm_Inhibit shall be present if Event_Algorithm_Inhibit_Ref is present.
10 If this property is present, then the Reliability property shall be present

Calendar Object	**BACnet 2012 Requirements**	**University of Minnesota Requirements**	**University of Minnesota Web Requirements**
Object_Identifier	R	R	R
Object_Name	R	R	R
Object_Type	R	R	R
Description	O	O	O
Present Value	R	R	R
Date_List	R	R	R
Property_List	R	R	R
Profile Name	O	Not Required	Not Required

Device	**BACnet 2012 Requirements**	**University of Minnesota Requirements**	**University of Minnesota Web Requirements**
Object_Identifier	R	R	Not Required
Object_Name	R	R	Not Required
Object_Type	R	R	Not Required
System_Status	R	R	Not Required
Vendor_Name	R	R	Not Required
Vendor_Identifier	R	R	Not Required
Model_Name	R	R	Not Required
Firmware_Revision	R	R	Not Required
Application_Software_Version	R	R	Not Required
Location	O	O	Not Required
Description	O	O	Not Required
Protocol_Version	R	R	Not Required
Protocol_Revision	R	R	Not Required
Protocol_Services_Supported	R	R	Not Required
Protocol_Object_Types_Supported	R	R	Not Required
Object_List	R	R	Not Required
Structured_Object_List	O	O	Not Required
Max_APDU_Length_Accepted	R	R	Not Required
Segmentation_Supported	R	R	Not Required
Max_Segments_Accepted	O1	O1	Not Required
VT_Classes_Supported	O2	O2	Not Required
Active_VT_Sessions	O2	O2	Not Required

Local_Time	O3,4,15	O3,4,15	Not Required
Local_Date	O3,4,15	O3,4,15	Not Required
UTC Offset	O4	O4	Not Required
Daylight_Savings_Status	O4	O4	Not Required
APDU_Segment_Timeout	O1	O1	Not Required
APDU_Timeout	R	R	Not Required
Number_Of APDU_Retries	R	R	Not Required
Time_Synchronization_Recipients	O5	O5	Not Required
Max Master	O6	O6	Not Required
Max_Info_Frames	O6	O6	Not Required
Device_Address_Binding	R	R	Not Required
Database_Revision	R	R	Not Required
Configuration_Files	**O7**	**O7**	Not Required
Last_Restore_Time	O7	O7	Not Required
Backup_Failure_Timeout	O8	O8	Not Required
Backup_Preparation_Time	O16	O16	Not Required
Restore_Preparation_Time	O16	O16	Not Required
Restore_Completion_Time	O16	O16	Not Required
Backup_A nd_Restore_State	O7	O7	Not Required
Active_COV_Subscriptions	O9	O9	Not Required
Slave_Proxy_Enable	O10	O10	Not Required
Manual_Slave_Address_Binding	O10,12	O10,12	Not Required
Auto_Slave_Discovery	O10,11	O10,11	Not Required
Slave Address Binding	O10,12	O10,12	Not Required
Last_Restart_Reason	O13	O13	Not Required
Time_Of_Device_Restart	O13	O13	Not Required
Restart_Notification_Recipients	O17	O17	Not Required
UTC_Time_Synchronization_Recipients	O5	O5	Not Required
Time_Synchronization_Interval	O14	O14	Not Required
Align_Intervals	O14	O14	Not Required
Interval_Offset	O14	O14	Not Required
Serial_Number	O	O	Not Required
Property_List	R	R	Not Required
Profile Name	O	Not Required	Not Required

1 These properties are required if, and shall be present only if, segmentation of any kind is supported.
2 These properties are required if, and shall be present only if, the VT services are supported.
3 If the device supports the execution of the TimeSynchronization service, then these properties shall be present.
4 If the device supports the execution of the UTCTimeSychronization services then these properties shall be present.
5 If present, this property shall be writable.
6 These properties are required if the device is an MS/TP master node.
7 These properties are required if, and shall be present only if, the device support execution of the backup and restore procedures.
8 This property is required if, and shall be present only if, the device supports the backup and restore procedures. If present, this property shall be writable.
9 This property is required if, and shall be present only if, the device support execution of either the SubscribeCOV or SubscribeCOVProperty service.
10 This property is required if, and shall be present only if, the device is capable of being a Slave-Proxy device.
11 This property is required if, and shall be present only if, the device is capable of being a Slave-Proxy device that implements automatic discovery of slaves.
12 This property shall be writable if the device is directly connected to an MS/TP network.
13 These properties are required if the device supports the restart procedure.

14 These properties are required if, and shall be present only if, Time_Synchronization_Recipients or UTC_Time_Sychronization_Recipients is present. If present, these properties shall be writable.
15 These properties shall be present if the device is capable of tracking date and time.
16 These properties are required if, and shall be present only if, the device supports execution of the backup and restore procedures and cannot respond to subsequent communications within the minimum value it will accept in its APDU_Timeout property.
17 This property is required if, and shall be present only if, the device supports execution of the restart procedure.

Multistate Input	BACnet 2012 Requirements	University of Minnesota Requirements	University of Minnesota Web Requirements
Object_Identifier	R	R	R
Object_Name	R	R	R
Object_Type	R	R	R
Present_Value	R1	R1	R1
Description	O	O	O
Device_Type	O	O	O
Status_Flags	R	R	R
Event_State	R	R	R
Reliability	O	O	O
Out_Of Service	R	R	R
Number_Of States	R	R	R
State_Text	O	O	O
Time Delay	O3,5	O3,5	O3,5
Notification_ Class	O3,5	O3,5	O3,5
Alarm_Values	O3,5	O3,5	O3,5
Fault_Values	O7	O7	O7
Event_Enable	O3,5	O3,5	O3,5
Acked_Transitions	O3,5	O3,5	O3,5
Notify_Type	O3,5	O3,5	O3,5
Event_Time_Stamps	O3,5	O3,5	O3,5
Event_Message_Texts	O4,5	O4,5	O4,5
Event_Message_Texts_Config	O5	O5	O5
Event_Detection_Enable	O3,5	O3,5	O3,5
Event_Algorithm_Inhibit_Ref	O5	O5	O5
Event_Algorithm_Inhibit	O5,6	O5,6	O5,6
Time_Delay_Normal	O5	O5	O5
Reliability_Evaluation_Inhibit	O7	O7	O7
Property_List	R	R	R
Profile Name	O	Not Required	Not Required

1 This property is required to be writable when Out_Of_Servie is TRUE.
2 Footnote removed.
3 These properties are required if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
4 This property, if present, is required to be read-only.
5 These properties shall be present only if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
6 Event_Algorithm_Inhibit shall be present if Event_Algorithm_Inhibit_Ref is present.
7 If this property is present, then the Reliability property shall be present.

Multistate Output	BACnet 2012 Requirements	University of Minnesota Requirements	University of Minnesota Web Requirements
Object_Identifier	R	R	R
ObjectName	R	R	R
Object_Type	R	R	R
Present_Value	W	W	W
Description	O	O	O
Device_Type	O	O	O
Status Flags	R	R	R
Event_State	R	R	R
Reliability	O	O	O
Out_Of Service	R	R	R
Number_Of States	R	R	R
State Text	O	O	O
Priority_Array	R	R	R
Relinquish_Default	R	R	R
Time Delay	O1,3	O1,3	O1,3
Notification_Class	O1,3	O1,3	O1,3
Feedback_Value	O1	O1	O1
Event_Enable	O1,3	O1,3	O1,3
Acked_Transitions	O1,3	O1,3	O1,3
Notify_Type	O1,3	O1,3	O1,3
Event_Time_Stamps	O1,3	O1,3	O1,3
Event_Message_Texts	O2,3	O2,3	O2,3
Event_M essage_Texts_Config	O3	O3	O3
Event_Detection_Enable	O1,3	O1,3	O1,3
Event_Algorithm_Inhibit_Ref	O3	O3	O3
Event_Algorithm_Inhibit	O3,4	O3,4	O3,4
Time_Delay_Normal	O3	O3	O3
Reliability_Evaluation_Inhibit	O5	O5	O5
Property_List	R	R	R
Profile Name	O	Not Required	Not Required

1 These properties are required if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
2 This property, if present, is required to be read-only.
3 These properties shall be present only if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
4 Event_Algorithm_Inhibit shall be present if Event_Algorithm_Inbibit_Ref is present.
5 If this property is present, then the Reliability property shall be present.

Multistate Value	BACnet 2012 Requirements	University of Minnesota Requirements	University of Minnesota Web Requirements
Object_Identifier	R	R	R
ObjectName	R	R	R
Object_Type	R	R	R
Present_Value	R1	R1	R1
Description	O	O	O
Status_Flags	R	R	R
Event_State	R	R	R
Reliability	O	O	O
Out_Of Service	R	R	R
Number_Of States	R	R	R
State Text	O	O	O
Priority_Array	O3	O3	O3
Relinquish_Default	O3	O3	O3
Time_Delay	O4,6	O4,6	O4,6
Notification_Class	O4,6	O4,6	O4,6
Alarm_Values	O4,6	O4,6	O4,6
Fault_Values	O8	O8	O8
Event_Enable	O4,6	O4,6	O4,6
Acked_Transitions	O4,6	O4,6	O4,6
Notify_Type	O4,6	O4,6	O4,6
Event_Time_Stamps	O4,6	O4,6	O4,6
Event_Message_Texts	O5,6	O5,6	O5,6
Event_Message_Texts_Config	O6	O6	O6
Event_Detection_Enable	O4,6	O4,6	O4,6
Event_Algorithm_Inhibit_Ref	O6	O6	O6
Event_Algorithm_Inhibit	O6,7	O6,7	O6,7
Time_Delay_Normal	O6	O6	O6
Reliability_Evaluation_Inhibit	O8	O8	O8
Property_List	R	R	R
Profile Name	O	Not Required	Not Required

1 If Present_Value is commandable, then it is required to also be writable. This property is required to be wriable when Out_Of_Service is TRUE
2 Footnote removed.
3 These properties are required if, and shall be present only if, Present_Value is commandable.
4 These properties are required if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**

Notification Class	BACnet 2012 Requirements	University of Minnesota Requirements	University of Minnesota Web Requirements
Object_Identifier	R	R	R
Object_Name	R	R	R
Object_Type	R	R	R
Description	O	O	O
Notification_ Class	R	R	R
Priority	R	R	R
Ack_Required	R	R	R
Recipient_List	R	R	R
Property_List	R	R	R
Profile Name	O	Not Required	Not Required

Schedule	BACnet 2012 Requirements	University of Minnesota Requirements	University of Minnesota Web Requirements
Object_Identifier	R	R	R
Object_Name	R	R	R
Object_Type	R	R	R
Present_Value	R	R	R
Description	O	O	O
Effective_ Period	R	R	R
Weekly_ Schedule	O1	W	W
Exception_Schedule	O1	W	W
Schedule_Default	R	R	R
List_Of Object_Property_References	R	R	R
Priority_For_Writing	R	R	R
Status Flags	R	R	R
Reliability	R	R	R
Out_Of Service	R	R	R
Event_Detection_Enable	O2,3	O2,3	O2,3
Notification_Class	O2,3	O2,3	O2,3
Event_Enable	O2,3	O2,3	O2,3
Event_State	O2,3	O2,3	O2,3
Acked_Transitions	O2,3	O2,3	O2,3
Notify_Type	O2,3	O2,3	O2,3
Event_Time_Stamps	O2,3	O2,3	O2,3
Event_Message_Texts	O3	O3	O3
Event_Message_Texts_Config	O3	O3	O3
Reliability_Evaluation_Inhibit	O	O	O
Property_List	R	R	R
Profile Name	O	Not Required	Not Required

1 At least one of these properties is required.
2 These properties are required if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
3 These properties shall be present only if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**

Trend	BACnet 2012 Requirements	University of Minnesota Requirements	University of Minnesota Web Requirements
Object_Identifier	R	R	R
Object_Name	R	R	R
Object_Type	R	R	R
Description	O	O	O
Enable	W	W	W
Start_Time	O1,2	O1,2	O1,2
Stop_Time	O1,2	O1,2	O1,2
Log_DeviceObjectProperty	O8	O8	O8
Log_Interval	O1,3	O1,3	O1,3
COV_Resubscription_Interval	O	O	O
Client COV_Increment	O	O	O
Stop_When_Full	R	R	R
Buffer_Size	R	R	R
Log_Buffer	R	R	R
Record_Count	W	W	W
Total_Record_Count	R	R	R
Logging_Type	R	R	R
Align_Intervals	O5	O5	O5
Interval_Offset	O5	O5	O5
Trigger	O	O	O
Status_Flags	R	R	R
Reliability	O	O	O
Notification_ Threshold	O4,7	O4,7	O4,7
Records_Since_Notification	O4,7	O4,7	O4,7
Last_Notify_Record	O4,7	O4,7	O4,7
Event_State	R	R	R
Notification_Class	O4,7	O4,7	O4,7
Event_Enable	O4,7	O4,7	O4,7
Acked_Transitions	O4,7	O4,7	O4,7
Notify_Type	O4,7	O4,7	O4,7
Event_Time_Stamps	O4,7	O4,7	O4,7
Event_Message_Texts	O6,7	O6,7	O6,7
Event_Message_Texts_Config	O7	O7	O7
Event_Detection_Enable	O4,7	O4,7	O4,7
Event_Algorithm_Inhibit_Ref	O7	O7	O7
Event_Algorithm_Inhibit	O7,9	O7,9	O7,9
Reliability_Evaluation_Inhibit	O10	O10	O10
Property_List	R	R	R
Profile Name	O	Not Required	Not Required

1 These properties are required if the monitored property is a BACnet property.
2 If present, these properties are required to be writable.
3 If present, this property is required to be writable when Logging_Type has the value POLLED or the value COV. Also, if present this property is required to be read-only if Logging_Type has the value TRIGGERED.
4 These properties are required if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
5 These properties are required if, and shall be present only if, the object supports clock-aligned logging.
6 This property, if present, is required to be read-only.

7 These properties shall be present only if the object supports intrinsic reporting. **University of Minnesota requires intrinsic alarming or algorithmic.**
8 This property is required if and shall be present only if the monitored property is a BACnet property.

University of Minnesota BACnet Services Minimum Requirements

BACnet Service	University of Minnesota Requirement
ALARM AND EVENT SERVICES	
Change of Value Reporting	
Event Reporting	
Event Algorithms	
Fault Algorithms	
AcknowledgeAlarm Service	
ConfirmedCOVNotification Service	
UnconfirmedCOVNotification Service	
ConfirmedEventNotification Service	
UnconfirmedEventNotification Service	
GetAlarmSummary Service	Required University of Minnesota Standard
GetEnrollmentSummary Service	
GetEventInformation Service	Required University of Minnesota Standard
LifeSafetyOperation Service	
SubscribeCOV Service	
SubscribeCOVProperty Service	
FILE ACCESS SERVICES	
AtomicReadFile Service	
AtomicWriteFile Service	
OBJECT ACCESS SERVICES	
AddListElement Service	Required University of Minnesota Standard For Use With Adding Recipient to Notification Class
RemoveListElement Service	Required University of Minnesota Standard For Use With Removing Recipient from Notification Class
CreateObject Service	
DeleteObject Service	
ReadProperty Service	
Deleted Clause	
Read PropertyMultiple Service	Required University of Minnesota Standard at Supervisory Controller Level
ReadRange Service	
WriteProperty Service	
WritePropertyMultiple Service	
WriteGroup Service	
REMOTE DEVICE MANAGEMENT SERVICES	
DeviceCommunicationControl Service	
ConfirmedPrivateTransfer Service	
UnconfirmedPrivateTransfer Service	
ReinitializeDevice Service	
ConfirmedTextMessage Service	
UnconfirmedTextMessaize Service	
TimeSynchronization Service	Required University of Minnesota Standard
UTCTimeSynchronization Service	

Who-Has and I-Have Services	
Who-Is and I-Am Services	

The BTL listing mark must be present on all supervisory controllers and BACnet MS/TP sub controllers.

End of Appendix A

APPENDIX B –CRITICAL ALARM STANDARD

The intent of this list is to provide a guide for those types of facility alarms considered “critical” which can be communicated to the PSECC via the BAS network. The total number of alarm points transmitted should be limited to only those that are necessary to protect the facility from damage. Multiple alarm points that indicate the same potential condition should be avoided.

Proper instructions for the PSECC Operator should be given and the instructions checked annually for accuracy. Other operational failure alarms can be transmitted via phone text message, email, or other sources of notification to the proper staff.

FIRE ALARMS

- Fire alarms received by the BAS can be transmitted to PSECC but are to be considered as redundant alarms. The BAS should not be the primary transmission method for fire alarms.

ALARM TEST

- A routinely scheduled test of the BAS communications network, which ensures alarms are being received by PSECC, should be programmed.

BOILER FAILURE / LOW HEATING WATER SUPPLY TEMPERATURE / HOT WATER CIRC PUMP FAIL

- The proper alarm(s) should be used to alert PSECC that the facility’s main heating system (or component) has or is failing. Limit the number of alarms while making sure your facility is protected.

LOSS OF POWER / EMERGENCY GENERATOR

- An alarm to indicate a facility power failure, generator running, or generator under load. Make sure the alarm instructions indicate the actual condition. This alarm can sometimes be wired so that the discontinuation/restoration of the alarm point indicates a restoration of normal power.

LOW SPACE TEMPERATURE

- This alarm should be used to protect an area vulnerable to low temperature damage. It can be physically located in an area known to be first to cool down during a heating failure, being a supplement to the boiler/heating failure alarm above.

SEWAGE EJECTOR HIGH LEVEL

- Indicates a system failure or potential failure.

LOW CONTROL AIR PRESSURE

- Indicates a potential failure of the air source controlling pneumatic controls.

CHILLER FAILURE / HIGH CHILLED WATER TEMP

- The proper alarm(s) should be used to alert PSECC that the facility main facility air conditioning system (or component) has or is failing. Limit the number of alarm points while making sure your facility is protected. Extra thought should be given as to whether this situation is critical to the facility.

AIR HANDLING UNIT FAIL OR LOW TEMP/FREEZE ALARM

- The proper alarm(s) can be used to alert PSECC that an air handling unit (or component) critical to the safety of the facility has or is failing. Limit the number of alarm points while making sure your facility is protected.

EXHAUST FAN FAIL

- The proper alarm(s) can be used to alert PSECC that an exhaust unit (or component) critical to the safety of the facility has or is failing. Limit the number of alarm points while making sure your facility is protected. Extra thought should be given as to whether this situation is critical to the facility.

OTHERS

- Other alarms that do not fall into these categories may be needed to protect certain facilities. It is the responsibility of each Building Operations Manager to make sure that the necessary alarm points are transmitted, and to be able to justify the need. It is our intent to limit the alarm activity transmitted to PSECC to those alarms that are truly critical.

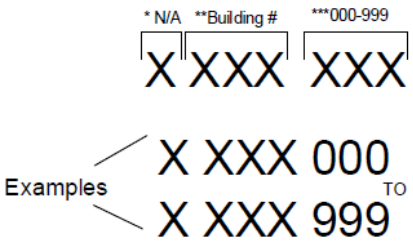
End of Appendix B

APPENDIX C: BACnet DEVICE AND NETWORK NUMBERING STANDARDS

BACnet Device and Network Number Standards

University of Minnesota BACnet Device Instance and Network Numbering Standard

BACnet IP Device Instance Numbering Standard

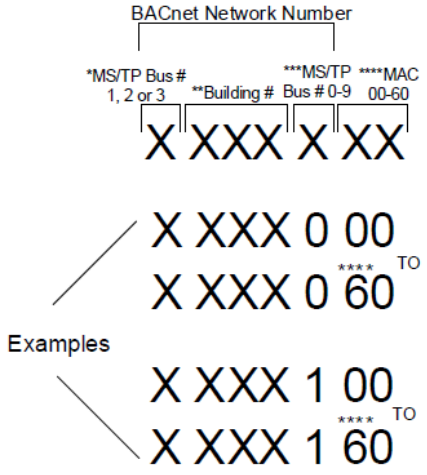


*Note: Not used for BACnet/IP devices.

**Note: If Building # is used again for another Building ending in a letter. Example: Building 123 and 123a please contact the Automation Group for correct 3 digit Building number which will begin with a 6 (6XX).

***Note: Start at 000 and increment throughout building as needed to 999.

BACnet MS/TP Device Instance and Network Numbering Standard



*Note: 1, 2 or 3 used for BACnet MS/TP devices.
Use 1 for first 10 buses in building
Use 2 for second 10 buses in building
Use 3 for third 10 buses in building
Works in conjuction with 5th digit

**Note: If Building # is used again for another Building ending in a letter. Example: Building 123 and 123a please contact the Automation Group for correct 3 digit Building number which will begin with a 6 (6XX).

***Note: Building MS/TP Bus # is not specific to any one BACnet router. Increment 1st digit (Max 3) if number of buses exceeds 10 in one building and start over 0-9. Max MS/TP buses per building is 30

****Note: 60 devices maximum per BACnet MS/TP bus. These 2 digits must match BACnet device MAC address.

Actual BACnet Device Instance Number Range 0-4194302

Actual BACnet Network Number Range 1-65534

Temperature Control Contractor shall set Max Master in each MS/TP Device properly. Do not leave the default setting (typically 127).

Device packing practice must be followed. All BACnet MS/TP devices must be "packed" so there are no unused MAC addresses between them.

End of Appendix C

APPENDIX D: BACnet ALARM RECIPIENT AND COMMAND PRIORITY STANDARD

All critical BACnet alarms shall be directed to the University of Minnesota primary PSECC BACnet alarm receiver via 1 of 3 notification class objects. *The BACnet Notification object* is a BACnet Object that is used to send event notifications within a BACnet System. The first BACnet notification class object shall be used for the highest priority alarms such as building freeze stat alarms, loss of control air, loss of main heating system, sump pump failures, BSL-3, greenhouses, RAR research, labs etc. Priority alarms shall be determined by University of Minnesota commissioning agent (see "Appendix B" for details). The second Notification class object shall be used for medium priority alarms that will be emailed to the proper recipient. The 3rd Notification class class object is for all low priority alarms that will not be sent to the University of Minnesota's PSECC BACnet alarm receiver or Email. This alarm will not be sent real time to any recipient but will be emailed to the proper recipient in the form of a complete list of alarms by others.

Notification object Critical shall contain device recipient 1006 (PSECC alarm receiver), device 1004. This recipient shall be setup for confirmed alarm transmission, handling type alarm, all days and times 24/7/365.
Notification object 03 shall contain device recipient 1001 (building engineer alarm receiver). This recipient shall be setup for unconfirmed alarm transmission, handling type alarm, all days and times 24/7/365.

All intrinsic alarm and event enrollment object names that are to be sent to Device 1006 (PSECC Interface) must contain the prefix "PSECC".

BACnet alarm priorities for notification class 01 (Critical Priority PSECC calls out immediately):
To: Off Normal Priority 50
To: Fault Priority 100
To: Normal Priority 150

BACnet alarm priorities for notification class 02 (High Priority Leave Message):
To: Off Normal Priority 50
To: Fault Priority 100
To: Normal Priority 150

BACnet alarm priorities notification class 03 (To building engineer only):
To: Off Normal Priority 50
To: Fault Priority 100
To: Normal Priority 150

BACnet Device Command Priorities Standards

BACnet Command Priority
1 Manual Life-Safety
2 Automatic Life-Safety
3 Available
4 Available
5 Critical Equipment Control
6 Minimum On/Off
7 Available
8 Manual Operator Override
9 Available
10 Available
11 Available

12 Available
13 Available
14 Available
15 Time Schedule
16 Operator Command

End of Appendix D

APPENDIX E: CRITICAL ALARM COMMISSIONING TEST

The Owner or Owners Representative must complete and sign off on the critical alarm test before the control system warranty period can start. The test is not intended to replace the Contractor's normal and accepted procedures for installing and pre-testing equipment or relieve the Contractor of standard checkout and start-up responsibilities, but to verify that critical alarms properly transmit to the PSECC interface.

General:

Temperature Control Contractor must expose points as BACnet alarms (intrinsic or algorithmic) and assign them to BACnet device 1006 (PSECC interface)

Expose all existing alarming points to BACnet/IP on the University of Minnesota LAN at subnet and UDP agreed on by Owner. Build notifications classes as described below and assign one recipient (PSECC BACnet alarm translator) at device address 1006. Assign and setup point objects as required.

A complete list of Intrinsic and algorithmic alarms showing the supervisory controllers BACnet UDP port and all object instance numbers must submitted to the Owner in a PDF format 5 days before test is conducted.

The BACnet Building Controller that is located in every building must send a properly formatted BACnet intrinsic or event enrollment alarm message (not COV) to the PSECC BACnet to SIA translator. The BACnet alarm (not event) message must include the BACnet destination object ID of 1006, process ID of 3 (set by BACnet to SIA translator), and a confirmed notification message type. Set points assigned to PSECC Notification class event enable To Off Normal, To Fault, To Normal

The temperature controls contractor shall setup alarms in each building based on University of Minnesota Alarming Standards as intrinsic or event enrollment. The “base load” of critical alarms should be configured with intrinsic reporting. The remaining complex situations should be configured using algorithmic reporting by creating individual event enrollment objects for each alarm. University of Minnesota will use the algorithmic reporting method when necessary to reduce the number of false alarms, specifically during normal equipment cycles and floating set point changes. The Controls Contractor shall make every effort to eliminate false alarms during 'normal' periods.

Notification Class Test:

Ensure each previously agreed upon alarm object is assigned to the newly created 'Critical Points To PSECC' notification class.

☐	Notification class object (alarm handlers) on all controllers transmitting alarms to PSECC have been created
☐	Object name and/or descriptor of notification class object is set to 'Critical Points To PSECC'
☐	Notification class is assigned to instance number 01. If already used on existing, indicate notification class number._____

☐	Notification recipient 1006 (PSECC Alarm Receiver) is present in the recipient list using Object ID entry method
☐	Recipient process ID has been set to 3
☐	Time and day is setup to transmit alarms to device 1006 for all dates and all times
☐	All 3 transition notifications are turned on. To Off Normal, To Fault, To Normal.
☐	Notification messages are set to 'Confirmed'
☐	All alarm priorities are set to 'Off Normal 50', To 'Fault 100', To 'Normal 150'
☐	Alarm type is set to 'Alarm' and not 'Event'
☐	Each agreed upon alarm object is assigned to the newly created 'Critical Points To PSECC' notification class object

Notification Class Test	**Pass:**	**Fail:**
Notes / Exceptions:		

Network Settings:

BACnet User Datagram Protocol (UDP) port assignment is set to the agreed upon UDP port for all BACnet devices. Enter UDP port number here._____

University of Minnesota BACnet Device Number Standards Setup for New Installations:

See appendix C for device and network number standards

Device Number Standards Setup	**Pass:**	**Fail:**
Notes / Exceptions:		

BBMD Test Support:

One supervisory controller on each separate University of Minnesota subnet is enabled with foreign device registration and setup for 10 users. The PSECC interface will register to this. Contractor shall send IP address

of BBMD that will allow foreign device registration and any other detailed information to Owner5 days before test. IP Address of BBMD_____

BBMD Test	**Pass:**	**Fail:**
Notes / Exceptions:		

Alarm and Event Services Test:

All alarms must be properly formatted and sent to PSECC interface and observed by Owner in real time during PSECC interface critical alarm test.

Each alarm object type listed below displays the alarm to the PSECC interface as follows: Present_Value changes to a new state for longer than Time_Delay AND the new transition is enabled in Event_Enable an intrinsic alarm shall be sent to the PSECC interface for the following standard BACnet objects:

☐	All Binary Input s if applicable successfully received at alarm region of PSECC interface
☐	All Binary Values if applicable successfully received at alarm region of PSECC interface
☐	All Multi-state Inputs if applicable successfully received at alarm region of PSECC interface
☐	All Multi-values Inputs if applicable successfully received at alarm region of PSECC interface

BI, BV, MSI, MSV Intrinsic Alarm Test	**Pass:**	**Fail:**
Notes / Exceptions:		

Each alarm object type listed below displays the alarm on the PSECC interface as follows: Present_Value exceeds range between High_Limit and Low_Limit for longer than Time_Delay AND the new transition is enabled in Event_Enable and Limit_Enable. An intrinsic alarm shall be sent to the PSECC interface for the following standard BACnet objects:

☐	All Analog Input s if applicable successfully received at alarm region of PSECC interface
☐	All Analog Outputs if applicable successfully received at alarm region of PSECC interface
☐	All Analog Values if applicable successfully received at alarm region of PSECC interface

AI, AO, AV Intrinsic Alarm Test	**Pass:**	**Fail:**
Notes / Exceptions:		

Each alarm object type listed below displays the normal to the PSECC interface as follows: If Present_Value returns within the High_Limit - Deadband to Low_Limit + Deadband range for longer than Time_Delay AND the new transition is enabled in Event_Enable and Limit_Enable. An intrinsic return to normal shall be sent to the PSECC interface for the following standard BACnet objects:

☐	All Analog Input s if applicable successfully received a return to normal at alarm region of

	PSECC interface
☐	All Analog Outputs if applicable successfully received a return to normal at alarm region of PSECC interface
☐	All Analog Values if applicable successfully received a return to normal at alarm region of PSECC interface

AI, AO, AV Intrinsic Normal Test	**Pass:**	**Fail:**
Notes / Exceptions:		

Each alarm object type listed below displays the normal to the PSECC interface as follows: If Present_Value differs from Feedback_Value for longer than Time_Delay AND the new transition is enabled in Event_Enable an intrinsic alarm shall be sent sent to the PSECC interface for the following standard BACnet objects:

☐	All Binary Outputs if applicable successfully received a return to normal at alarm region of PSECC interface
☐	All Multistate Outputs if applicable successfully received a return to normal at alarm region of PSECC interface

BO, MSO Intrinsic Alarm Test	**Pass:**	**Fail:**
Notes / Exceptions:		

Algorithmic Alarm Test:

Change of state:

Each event enrollment change of state type displays the alarm to the PSECC interface as follows: If Present_Value changes to a new state for longer that Time_Delay AND the new transition is enabled in Event_Enable. An algorithmic alarm shall be sent to the PSECC interface alarm region

Algorithmic COS	**Pass:**	**Fail:**
Notes / Exceptions:		

Command failure:

Each event enrollment command failure type displays the alarm to the PSECC interface as follows: If Present_Value differs from Feedback_Value for longer than Time_Delay AND the new transition is enabled in Event_Enable. An algorithmic alarm shall be sent to the PSECC interface alarm region

Algorithmic Command Failure	**Pass:**	**Fail:**
Notes / Exceptions:		

Floating limit:

Each event enrollment floating limit type displays the alarm to the PSECC interface as follows: If Setpoint_reference returns or leaves from within the High_Differential_Limit or Low_Differential_Limit - Deadband to High Differential Limit or Low Differential Limit + Deadband range for longer than Time_Delay AND the new transition is enabled in Event_Enable and Limit_Enable. An algorithmic alarm or return to normal shall be sent to the PSECC interface alarm region

Algorithmic Floating Limit	**Pass:**	**Fail:**
Notes / Exceptions:		

Out of range

Each event enrollment out of range type displays the alarm to the PSECC interface as follows: If Present_Value returns or leaves from within the High_Limit or Low_Limit - Deadband to High_Limit or Low_Limit + Deadband range for longer than Time_Delay AND the new transition is enabled in Event_Enable and Limit_Enable. An algorithmic alarm or return to normal shall be sent to the PSECC interface alarm region

Algorithmic Out of Range	**Pass:**	**Fail:**
Notes / Exceptions:		

Alarm Services Test:

Owner shall restart PSECC interface and run alarm summary service after alarm is sent.

☐	Get Event Info. Coordinate and conduct test with owners rep
☐	Get Alarm Summary. Coordinate and conduct test with owners rep

Alarm Services Test	**Pass:**	**Fail:**
Notes / Exceptions:		

End of Appendix E

APPENDIX F: COMMISSIONING CHECKLIST

The Commissioning Agent in coordination with the Controls Contractor shall complete and sign off on all checklist tasks prior to the start of control system warranty. In addition, the Commissioning Agent and Controls Contractor shall arrange a review meeting with the Owner, after all the checklist tasks are completed, to demonstrate that all of the commissioning checklist tasks are done to the satisfaction of the Owner.

COMMISSIONING CHECKLIST FOR CONTROLS

Task #	Description of Task	Cx Agent Sign-Off Initials	Control Contractor Sign-Off Initials	Owner Sign-Off Initials
1	O&M Documents have been submitted to the U of M Commissioning agent and are complete and accurate.			
2	The Sequence of Operation is complete and accurate.			
3	The O&M Documents and Sequence of Operation are viewable from the control system.			
4	As-Built Drawings have been submitted to the U of M Commissioning agent and are complete and accurate.			
5	The As-Built Drawings show all devices and wiring.			
6	All adjustable points are displayed on the graphics.			
7	All adjustable points have been tested and function per design.			
8	Control system software and tools have been furnished.			
9	Final Test & Balance report has been provided (if TAB is subcontractor to Controls Contractor)			
10	Control system training per specifications has been provided.			
11	Control system software and tools have been furnished.			

End of Appendix F

END OF DIVISION 25 – INTEGRATED CONTROLS