Section Number | Title

25 00 00 INTEGRATED AUTOMATION GENERAL REQUIREMENTS

Part 1 – General

1. SUMMARY

A. This section includes general requirements for furnishing, installing, and integrating new Direct Digital Controls into the Owner's Building Automation System.
B. Related Sections:
   1. 23 08 00 Commissioning of Mechanical Systems (HVAC systems and controls)
      a. Commissioning requirements for this section are contained in Section 23 08 00.
   2. 25 11 00 Integrated Automation Network Devices
   3. 25 12 00 Integrated Automation Network Configuration
   4. 25 14 00 Integrated Automation Field Devices
   5. 25 15 00 Integrated Automation Software
   6. 25 36 00 Integrated Automation Instrumentation and Terminal Devices
C. Coordination with other trades is required wherever architectural features govern the location of work.
D. References
   1. Any rules and regulations of Federal, State, local authorities, and utility companies in force throughout the contract duration.
   2. Agencies relevant to this specification:
      a. ANSI American National Standards Institute
      b. ASHRAE American Society of Heating, Refrigeration, and Air-Conditioning Engineers
      c. BTL BACnet Testing Laboratories
      d. FCC Federal Communications Commission
      e. IEC International Electrotechnical Commission
      f. ISO International Organization for Standardization
      g. NEC National Electrical Code
      h. NEMA National Electrical Manufacturers Association
      i. OSHA Occupational Safety and Health Administration
      j. UL Underwriters Laboratories

E. Publications relevant to this specification:
   1. ANSI/ASHRAE Standard 135-2016, A Data Communication Protocol for Building Automation and Control Networks
   2. ASHRAE Guideline 36 – High Performance Sequences of Operation for HVAC Systems
   3. ASHRAE 223P (expected 2019) – Designation and Classification of Semantic Tags for Building Data
   4. ISO 16484-5:2017 – Building Automation and Control Systems (BACS) -- Part 5: Data communication protocol
   5. NEMA 250-2014 – Enclosures for Electrical Equipment (1000 Volts Maximum)
   6. TIA/EIA-485 (1998) – Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems
   7. TIA/EIA-568 (2015) – Commercial Building Telecommunications Cabling Standard
   8. UL 916 (2015) – Energy Management Equipment

F. The latest editions of the publications noted in section 1.2.C shall apply to the BMS design and installation as applicable, as well as any approved addenda or amendments.

2. ACRONYMS

A. B-AAC BACnet Advanced Application Controller – Profile with criteria defined by BACnet International
B. B-ASC BACnet Application Specific Controller – Profile with criteria defined by BACnet International
C. B-BC BACnet Building Controller – Profile with criteria defined by BACnet International
D. BAS Building Automation System – The entire integrated management and control system
E. BBMD BACnet Broadcast Management Device capable of forwarding BACnet broadcast messages across subnetworks.
F. BIBB BACnet Interoperability Building Blocks – Standardized documentation of a devices BACnet functionality across the network.
G. 7BMS Building Management System. Used interchangeably with BAS.
H. BTL BACnet Testing Laboratories supports interoperability testing for BACnet device
I. EMS Energy Management System

J. COV Change of Value – Trending increment that records data every time a value changes a pre-specified amount.
K. DDC Direct Digital Controller – Microprocessor-based control including Analog/Digital conversion and program logic.
L. PID Proportional, Integral, Derivative – Control algorithm used to adjust an output based upon the difference between a process variable and setpoint variable
M. INT Interval – Trending increment that records data on a pre-defined time interval.
N. IP Internet Protocol – Set of rules governing the format of data sent over the internet or other networks
O. GUI Graphical User Interface – Term for any graphical interface allowing user to read/write data
P. LAN Local Area Network – A collection of devices interconnected in one physical location
Q. O&M Operations and Maintenance – Term to define documentation that illustrates both the operation and maintenance of a product.
R. PICS Protocol Implementation Conformance Statement used to describe the BACnet capabilities of a device
S. SaaS Subscription as a Service – Service or application subscribed for use on while on a re-occurring payment.
T. SLA Service Level Agreement – A commitment between a service provider and a client.
U. UDP User Datagram Protocol
V. XML Extensible Markup Language – A markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable.

3. DEFINITIONS

A. Algorithm A process or set of rules to be followed in calculations or other problem-solving operations
B. BACnet Building Automation and Control Networks communication protocol developed by ASHRAE
C. BACnet Object The concept of organizing BACnet information into standard components with various associated properties
D. Bridge A repeater that connects two LANs on same network protocol across different data link layers
E. Cloud Referencing any data storage on an off-site location not maintained by the client
F. Controls Contractors The contractors installing and configuring the devices being installed on the Owner's network

G. Date of acceptance The date determined between the Owner and the contractor that the equipment is finalized and tested, and is turned over to the Owner
H. Device Term for any type of DDC or network component used for monitoring or control
I. Enterprise Software used to satisfy the needs of an organization. Used as the interface for all integrated building management equipment
J. Ethernet A computer networking architecture consisting of various local-area networking protocols and devices
K. Equipment Term referencing a controlled component
L. FAULT BACnet Notification state indicating that loss of communication or sensor
M. Firmware Permanent software programmed into read-only memory and provides low level hardware control
N. Gateway Connects two dissimilar protocols by translating the data from one system to another system
O. Integration Contractor The contractors responsible for the integration of the devices being installed on the Owner network
P. Integration Project Any project requiring data passing between installed controls any of the Owner systems, including but not limited to the BAS Supervisor
Q. Hub A common connection point for devices on a network
R. Integrate The act of connecting disparate BMS systems to a common platform
S. Integrator Integrates one system into another by acting as both a router and a gateway, and is capable of other functions including trending, scheduling, notifications, and other programming features
T. IP Address A unique string of numbers separated by periods that identifies each computer using the internet protocol to communicate over a network
U. Loop Synonymous with PID
V. The Owner Referring to Northern Arizona University
W. Network Multiple devices communicating with one another
X. Non-Programmable A device that has pre-programmed language or logic that cannot be re-written or only has pre-selectable options
Y. Notification Object A BACnet Object that is used to send event notifications, including alarms, within a BACnet System
Z. Object Data or packet or data on a network
AA. OFFNORMAL BACnet Notification state indicating that a parameter is met to indicate an off normal event

BB. Points Software representation of virtual and physical inputs and outputs

CC. Programmable A device that does not have any pre-programmed language or logic.

DD. Repeater A device used to replicate signal data in order to increase transmission distance

EE. Router Routes data packets across IP addresses on different LANs/WANs with the ability to allow or deny

FF. Subnet Also known as a subnetwork, is a logical subdivision of a network

GG. System Term referencing multiple pieces of equipment acting in conjunction

4. SYSTEM DESCRIPTION
   A. The Owner has standardized an open system architecture for complete integration of new and existing components of the building automation system. This open system standardization will ensure continued building automation system interoperability between all sub-systems and shall be designed for stand-alone operation in the event of a communication failure.
   B. The Owner has standardized the use of Niagara N4 for their graphical user interface with Distech as the building controllers.

5. PRICING

   RESERVED

6. INTEGRATION WITH EXISTING BUILDING MANAGEMENT SYSTEM
   A. The Integration Contractor shall include all services needed to integrate the existing Alerton BMS and new BACnet controllers installed for the pneumatic to DDC project into The Owner's Niagara N4 system.
   B. Procedure
      1. All controls work noted on the drawing set and within this document shall be provided by the Integration Contractor.
      2. Develop all building level control system databases and field device control programming using existing standards. Standardized programs shall be created based on equipment type. Subset programs within the same equipment type are permitted if the device is controlling/monitoring peripheral equipment.

3. New graphics shall be created on the Niagara N4 system for the existing Alerton BMS and new BACnet controllers installed for the pneumatic to DDC project. See sections *25 14 00 – Integrated Automation Field Devices* and *25 15 00 – Integrated Automated Software* for graphical user interface, trending, and alarming requirements.
4. As new devices are brought into Niagara N4, these devices shall be made available to the Owner's operations and maintenance personnel for monitoring and control from the Niagara N4 system.

7. SEQUENCES OF OPERATION
   To be detailed on the plans through submittal and permitting reviews.

8. SUBMITTALS
   A. Submittals must be reviewed by the Owner, the Design Professionals, and/or an Owner's Representative for conformity with the design intent. Execution of work will not be performed until the related submittals have been reviewed for conformity with the design intent and the Contractor has responded to all comments to the satisfaction of the Owner, the Design Professional and/or the Owner's Representative.
   B. The Controls Contractor and Integration Contractor are required to provide their submittals in a timely manner to allow for timely review, resubmittal as needed, and final review before proceeding with work. Failure to submit in timely manner does not alleviate the Controls Contractor and Integration Contractor from meeting the project schedule unless they receive approval of schedule change by the Owner.
   C. The submittal schedule shall be as follows unless otherwise directed by the Owner:
      1. The first submittal package shall consist of Hardware and Shop Drawings and shall be submitted with a schedule established by the Owner in project related bid documents.
      2. The second submittal package shall consist of Programming and Graphics and shall be submitted no less than 30 days before software installation and system integration.
      3. The third submittal package shall consist of training materials and checkout forms and shall be submitted no less than 14 days prior to requesting a training date.
   D. Submission and Resubmission Procedure:
      1. All documents shall be in a word searchable format.

2. Electronic submittals indicated below can be submitted unofficially as Pre-Submittals via email directly to the Engineer for review and comment prior to formal submission. Comments provided by the Engineer are not official and may be changed or additional comments may be provided on the formal submittal. The intent of pre-submittals is to reduce paperwork and review time.
3. Each submittal shall have a unique serial number that includes the associated specification section followed by a number for each sub-part of the submittal for that specification section, such as SUBMITTAL 25 34 00.
4. Each resubmittal shall have the original unique serial number plus unique revision number such as SUBMITTAL 25 34 00 REV.1.
5. Submit one copy of submittal in electronic format specified under each submittal package below. Submissions made in the wrong format will be returned without action.
6. Owner's Representative will return a memo or mark-up of submittal with comments and corrections noted where required.
7. When making corrections:
    a. Revise the initial submittal to resolve review comments and corrections.
    b. Indicate any changes that have been made other than those requested.
    c. Clearly identify resubmittal by original submittal number and revision number.
8. Resubmit revised submittals until no exceptions are taken.
9. Once submittals are accepted with no exceptions taken, provide the following:
    a. Complete submittal of all accepted drawings and products in a single electronic file.
    b. Electronic copies for coordination with other trades.

E. Submittal Package for Hardware and Shop Drawings:

1. Hardware:
    a. Do not submit products that are not used even if included in specifications.

b. Include a summary table of contents listing for each device submitted for this project. The table shall include:
    i. Location of device within the submittal package (page number or tab)
    ii. Device tag noted within this specification and the drawing set.
    iii. Whether the device is per specification or a substitution.
    iv. Manufacturer
    v. Model
    vi. Device Accuracy (if applicable)
c. The submittal shall include:
    i. Manufacturer's description
    ii. Manufacturer's performance and technical data
    iii. Product specification sheets
    iv. Installation instructions
    v. PICS statement, BIBB, and BTL listing documents for all BACnet devices
d. Manufacturer datasheets that contain a series of components must clearly indicate the specific component that is applicable to this project.
e. Each submitted piece of manufacturer literature will clearly reference the specification or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements.

2. Submittal Package for Shop Drawings
    a. General Shop Drawing Format:
        i. Sheets shall be consecutively numbered.
        ii. Each sheet shall have a title indicating the type of information included and the mechanical/electrical system controlled.
        iii. Table of Contents listing sheet titles and sheet numbers.
        iv. Legend and list of abbreviations.
        v. All schematics, diagrams, and floorplans listed below.
    b. System architecture one-line diagram indicating schematic location of all field devices, workstations, gateways, switches, etc. The

following information shall also be noted on the system architecture one-line diagram:

i. Network ID for each individual network

ii. Device IDs for each device

iii. DHCP configuration for IP devices

iv. Previous device in daisy chain installation

v. Hosted Network Information

c. Schematic flow diagrams for each air, hydronic, and steam system that clearly indicate fans, coils, valves, dampers, pumps, heat exchanging equipment and control devices.

d. Schematic flow diagrams will reflect schematics provided on the project drawings set with respect to layout and location of control points.

e. All physical points on the schematic flow diagram shall be indicated with point naming matching the Owner's standard, descriptors, and point addresses identified as listed in the point summary table. Each physical point shall be labeled with their appropriate range.

f. Device layout for each unique device requiring the following information:

i. Device layout with enclosure information, enclosure ID, device name, IP address, Device ID, and manufacturer make and model number.

ii. Connection to all peripheral equipment with point naming matching the Owner's standard, wiring layouts, and bill of material.

iii. Location of installation for each device and expansion module including panel numbers.

iv. Power wiring including power source location, electrical panel number, and breaker number.

v. Communication wiring including the previous and next device if daisy chain configuration, and switch/port information if IP device.

vi. All electrical wiring diagrams shall be included. Provide both ladder logic type diagrams for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers

identified. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

g. The bill of materials provided with each device layout shall include all materials and equipment, including:
   i. Device tags as indicated in the schematic and actual field labeling. Tags shall be used as indicated in these specifications where applicable.
   ii. Description.
   iii. Proposed manufacturers make and model.
   iv. Range.
   v. Quantity.

h. Valve sheet providing valve and actuator information, including:
   i. Pipe and valve size
   ii. Cv
   iii. Design flow
   iv. Target pressure drop
   v. Proposed manufacturers make and model
   vi. Close off rating
   vii. Normal position of failsafe actuators

i. Floorplans noting proposed integration controller and field device installation locations and thermostat locations.

3. Submittal Package for Programming and Graphics
   a. A detailed description of point naming convention conforming to the Owner's standard to be used for all software and hardware points, integrated with existing database convention.
   b. A list of all hardware and software points identifying their full text names, device addresses and descriptions.
   c. Control logic program listings consistent with the specified Sequences of Operation for all proposed equipment for this project. Control logic shall be annotated to describe how it accomplishes their respective Sequences of Operation and shall be sufficient to allow an operator to relate each program component

to their corresponding portions of their respective Sequences of Operation.

i. Include clearly marked Sequences of Operation of each control sequence that are updated to reflect any suggested changes made by the Controls Contractor or Integration Contractor to clarify, expand upon, or improve the sequences including but not limited to providing details on trim and respond setpoints. New Sequences of Operation shall be fully consistent with the graphical programming.

ii. Include control settings, setpoints, throttling ranges, reset schedules, adjustable parameters and limits.

iii. Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation.

d. Graphics screens for all required graphics. See section *25 15 00 – Integrated Automated Software* for Graphical User Interface Requirements.

e. Additional hardware and software requirements for any proposed software installations as stated in section *25 15 00 Integrated Automation Software.*

f. Training Material and Checkout Forms
The following will be provided as part of the Checkout Forms for each device. The checkout form will include, but is not limited to, the following:
   i. Point-to-point testing (see also the Commissioning Specification 23 08 00).
   ii. Device Communication Status
   iii. Communication Errors and Repair Requirements
   iv. GUI Function Tests at All Operator Stations
   v. See Section 11 for Training Material requirements.

9. COMPLETION REQUIREMENTS

A. Controls and Integration Substantial Completion

1. The building has received a Temporary Certificate of Occupancy or a Certificate of Occupancy.

2. Each system is operating per the design Sequence of Operation. Where Building Commissioning is part of the project scope, Commissioning has been completed and any remaining issues do not affect system operation.
3. There are no network communication issues that prevent the owner from adequately operating and maintaining the equipment.
4. The GUI is fully functional, every system is able to be controlled by the Owner, and any remaining issues are aesthetic in nature.

B. Procedure:

1. Until the documents required in this section are submitted and accepted, the system will not be considered accepted and final payment to Contractor responsible for providing the documentation will not be made.
2. Before requesting acceptance of Work, submit one set of completion documents for review and approval of Owner.
3. After review, furnish quantity of sets indicated below to the Owner.

C. Record Documents:

1. Operations and Maintenance manuals in both paper and electronic formats. These manuals shall include:
   a. Product data, shop drawings, control logic documentation, sequence of operation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists.
   b. As-built versions of the submittal data. Submittal data shall be located in tabs along with associated maintenance information.
   c. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables
2. Licenses, guarantees, and warranty documents for equipment and systems.

10. QUALITY ASSURANCE

A. Coordinate all related network infrastructure changes with the Owner. Any changes to network components or infrastructure without prior authorization from the Owner is not permitted.

B. Materials and equipment will be the catalogued products of manufacturers who regularly engage in production and installation of building automation systems. Materials and equipment will be the manufacturer's latest design that complies with the specification requirements.

C. All hardware, software, components, and accessories must be:

1. New from the factory
2. In production and not a legacy product
3. Supported by the manufacturer
4. Free of defects
5. Provided by the same manufacturer for each product type throughout the duration of the project

D. Follow project communication protocol for all correspondence. Any changes, decisions, etc. must be properly documented. Verbal interpretations, clarifications, conversations, etc., are non-binding without proper documentation.

E. RFIs sent to the Owner are to address individual requests only with a proposed solution. Multiple issues or incomplete RFI's will be rejected. RFIs will include, but not limited to, the following:

1. Referenced Drawing
2. Referenced Specification Number/Section
3. Contact Person
4. Request and Proposed Solution

F. RFI answers are for clarification only and do not authorize additional work or change orders.

G. Controls Contractor Personnel Requirements:

1. The Controls Contractor shall have a minimum of five (5) years of demonstrated technical expertise with building automation system operation, maintenance, and service. The Controls Contractor must also provide documented proof of servicing installations of similar or greater size and complexity as well as provide documented proof of servicing the proposed lines for a minimum of 1 year.
2. The Controls Contractor Program Manager shall have a minimum of three (3) years of experience with DDC system installation and must

have experience with the installation of the proposed devices on a minimum of two (2) projects of similar or greater size and complexity.

3. The Controls Contractor Programmer(s) and Lead Installation Technician shall have a minimum of three (3) years of experience with DDC system installation and programming and must have experience with the installation and programming of the proposed devices for a minimum of two (2) years.
4. The Controls Contractor Project Manager and Programmer(s) must supply proof of successfully completing the most advanced training offered by the manufacturer of the proposed devices to proficiently install, program, and commission the proposed devices.
5. The Controls Contractor Lead Installation Technician must supply proof of successfully completing training offered by the manufacturer of the proposed devices to proficiently install the proposed devices.

H. Integration Contractor Personnel Requirements:

1. The Integration Contractor shall have a minimum of five (5) years of demonstrated technical expertise with building automation system integration. The Integration Contractor must also provide documented proof of servicing installations of similar or greater size and complexity as well as provide documented proof of servicing the proposed devices for a minimum of one (1) year.
2. The Integration Contractor Program Manager shall have a minimum of three (3) years of experience with BMS integration and must have experience on a minimum of two (2) projects utilizing the proposed devices for projects of similar or greater size and complexity.
3. The Integration Contractor Programmer(s) shall have a minimum of three (3) years of experience with BMS integration, programming, and graphical user interface generation and must have a minimum of two (2) years' experience providing integration services for the proposed devices.
4. The Integration Contractor Project Manager and Programmer(s) must supply proof of successfully completing the most advanced training offered by the manufacturer of the proposed devices to proficiently integrate, program, and generate graphics for the proposed devices.

I. The Owner reserves the right to make the final determination of the qualifications of any Contractor's employees and will have the Contractor's employees removed from the project if they so choose. The Owner will make a request in writing to Contractor citing the circumstances and the

Contractor will replace any unqualified employee within three (3) business days with no impact to project schedule.

J. Contractor is responsible for replacing sections of insulation where devices (meters, valves, sensors, etc.) are installed in locations where they are removed and cleaning up the area after installation.

11. WARRANTY

A. See contract document for warranty requirements.

B. Warranty documentation will be submitted for acceptance to the Owner upon completion of the project. The Owner and/or a consultant on behalf of the Owner will provide written acceptance once it has been determined that the building management system functions satisfactorily during the testing and commissioning phase.

C. Vendor specific warranty information will be provided as part of the Controls Contractor and Integration Contractor warranty documentation. Any manufacturer's warranty that exceeds 24 months will be extended to the Owner.

D. The warranty start date will be the date of acceptance and will be for a period of 12 months after final acceptance.

E. Device failures during the warranty period will be adjusted, repaired, or replaced with no additional cost to the Owner.

F. Any standard troubleshooting or routine maintenance completed by the Owner will not void any warranty or incur any additional costs.

G. The Controls Contractor and Integration Contractor will be capable of responding (onsite if needed) during normal business hours within 24 hours of a warranty service request.

H. All corrective software modifications made during the warranty period will be updated on all project documentation and updated software files will be provided to the Owner for record purposes.

I. Software fixes and firmware updates will be covered throughout the warranty duration with no additional cost to the Owner. With approval of the Owner and assurance that no existing equipment connections will be adversely affected, patches and updates will be applied within 72 hours of becoming available from the manufacturer.

J. At the end of the warranty period, the Integration Contractor will be responsible for verifying any instance of Tridium Niagara software and firmware is updated to the latest revision.

K. Expiration of the warranty period does not relieve the Controls Contractor or Integration Contractor of the responsibility to:

1. Correct all deficiencies identified during the warranty period.
2. Fulfill all specified obligations during the warranty period.

L. The Contractor will not be required to warranty reused devices, except those that have been rebuilt or repaired. Reused devices must demonstrate they are in operable condition at the time of acceptance.

M. Parts, labor, and travel will be included during the warranty duration.

12. OWNER TRAINING

A. Coordinate schedule and materials with the Commissioning Provider.

B. Training will not be scheduled until all integrated systems and GUI components are completed, functional, and all commissioning has been completed.

C. If device integration coincides with other subsystem installation, Owner training for subsystems may be completed in parallel with training mentioned within this specification.

D. Based upon project size, a minimum of 8 hours of training will be provided to the Owner, organized into 2 separate sections at 4 hours a piece, unless otherwise stated by the Owner.

E. Provide a factory-trained instructor or representative to give full instructions to designated personnel in the operation, maintenance, and programming of each piece of equipment or system. Instructors shall be thoroughly familiar with all aspects of the subject matter. The Contractor will provide all equipment and material required for classroom training.

F. Proposed training instructor qualifications will be provided to the Owner and subject to approval by the Owner.

G. Training will include classroom instruction and hands-on field instruction.

H. Minimum requirements for classroom instruction are the following:

1. Review of project record documentation
2. Maintenance procedures and schedules
3. Any pertinent safety requirements

4. Operator control functions
5. GUI navigation, including:
    a. Login/logout procedures, password setup, and audit log reporting
    b. Menu penetration and broad overview of the various functions and features
6. Explanation of controller backup procedures
7. Explanation of procedures to restore any database. Scenarios to explain include:
    a. Corrupted database restoration
    b. Restoration of database in a new controller
8. A detailed review of programming, trending, and alarm database management.
9. Training manuals will be provided and include screen captures with detailed instructional annotation for each step required to complete all portions of the training.
10. Additional topics can be requested by the Owner in advance of the training sessions. Each additional topic will require the Contractor to prepare and submit training manuals with the same level of detail as described above.
11. All training is to be recorded by the contractor and turned over to the Owner.

I. Minimum requirements for field instruction:

1. Walkthrough of the project to locate integrated components
2. Demonstration of operation from Supervisor to integrated equipment

13. OWNERSHIP OF PROPRIETARY MATERIAL

A. Project specific software and all related documentation will become the property of the Owner. This includes, but is not limited to, the following:

1. Graphical Templates
2. Project Record Drawings
3. Station Databases
4. Custom Logic

Section Number | Title

PART 2 – PRODUCTS

N/A

PART 3 – EXECUTION

1. EXAMINATION

   A. Perform site inspection prior to work performed to verify equipment can be installed as noted in the project documentation.

   B. Report any discrepancies, conflicts, inadequate conditions, or omissions related to project documentation to Engineer. Resolution must be provided prior to starting rough-in work. Report unacceptable conditions immediately.

   C. Promptly request clarification and instruction related to project documentation through the proper RFI procedure.

2. PROJECT MANAGEMENT

   A. The contractors may be split into a Controls Contractor and an Integration Contractor. If the Controls Contractor and the Integration Contractor are the same contractor, approval for each submittal by the Owner is still required.

   B. The Contractor will attend all project meetings and provide meeting minutes and action items to all meeting attendees.

   C. Meeting minutes will represent a true and accurate record of the project meeting

   D. Corrections or clarifications to project meeting minutes will be provided by the Contractor within 7 days of the issuance date of the project meeting minutes.

   E. The Contractor will provide an updated project schedule, with all applicable milestones, at least 1 day prior to the project meeting.

   F. The Contractor's Project Manager, Programmer(s), and Lead Installation Technician will be required to attend all project meetings.

   G. The Contractor accepts that the Owner may rely on third party consultants to complete an independent review of the Contractor provided project deliverables.

H. The Contractor will maintain red lined copies of as-built drawings on site at all times.

3. BUILDING MANAGEMENT SYSTEM SWITCH OVER

A. Switch over from an existing building management system to the new building management system will be coordinated with the Owner. A representative of the Owner may be on site during switch over.

B. Any required downtime to subsystems scheduled for integration into the building management system will be limited to 24 hours.

1. For integration of HVAC equipment, space temperatures must be maintained in occupied spaces levels approved by the Owner throughout the duration of any expected building management system downtime.

C. Controller performance tests of integrated equipment will be performed once integration and switch over has been completed.

1. The Integration Contractor will allow time to perform function tests of all integrated equipment with a consultant on behalf of the Owner prior to project completion.
2. See section *25 14 00 – Integrated Automation Field Devices* for functional test requirements.

4. BUILDING MANAGEMENT SYSTEM EQUIPMENT DEMOLITION

A. Demolition of existing building management system hardware and/or software scheduled for replacement will not occur until the Owner has confirmed demolition may commence.

1. The Integration Contractor will be responsible for steps taken to minimize equipment outages wherever possible.

2. A demolition plan will be submitted to the Owner for approval. The demolition plan must be submitted no later than two weeks prior to commencement of work on site.

3. Demolished building management system hardware will be handed over to the Owner once demolition is complete, unless otherwise stated by the Owner.

****END OF SECTION****

Section Number | Title

25 11 00 INTEGRATED AUTOMATED NETWORK DEVICES

PART 1 – GENERAL

1. SUMMARY
   A. This section defines the requirements for any network equipment required to move data between networks or translate data to an IP network layer.
   B. Related Sections:
      1. *25 00 00 Integrated Automation*
      2. *25 14 00 Integrated Automation Local Control Units*
      3. *25 15 00 Integrated Automation Software*
      4. *25 36 00 Integrated Automated Instrumentation and Terminal Devices*
2. REFERENCES
   A. Refer to *25 00 00 Integrated Automation.*
3. ACRONYMS
   A. Refer to *25 00 00 Integrated Automation.*
4. DEFINITIONS
   A. Refer to *25 00 00 Integrated Automation.*
5. SYSTEM DESCRIPTION
   A. Refer to *25 00 00 Integrated Automation.*
6. SUBMITTALS
   A. Refer to *25 00 00 Integrated Automation.*
7. QUALITY ASSURANCE
   A. New devices used for transport of BACnet data must be native-BACnet and BTL listed unless otherwise approved by the Owner.
   B. Coordinate all related network infrastructure changes with the Owner before execution of the work.
   C. Network configuration and device identification is configured by the Owner and must be pre-approved prior to set-up and execution.
   D. The Integration Contractor shall confirm compatibility between supervisory software and server hardware.

E. Any new BMS related devices shall have an administrative user setup for authorized Operations and Maintenance personnel. All default user and administration accounts shall be deactivated or removed.

F. Refer to *25 00 00 Integrated Automation* for additional quality assurance requirements.

8. WARRANTY

A. Refer to *25 00 00 Integrated Automation.*

PART 2 – PRODUCTS

1. GENERAL REQUIREMENTS

A. Any network device proposed for permanent installation must adhere to the following:

1. Must utilize BACnet/IP as one of its primary communication protocols and must be discoverable on any BACnet network.
2. Must be license and maintenance cost free to remain functional with any BACnet system.
3. Must have full set-up and configuration available through IP address connection in web browser.
4. Must come with a secondary RJ45 communication port for temporary local connection to the controller. This connection must support data backup, commissioning, programming, and configuration functions.
5. Must not be limited in their ability to communicate with a specific brand or model with exception of approved gateways for proprietary network applications.

2. MANUFACTURED UNITS

A. Acceptable Manufacturers for BACnet Routers:

1. Contemporary Controls
2. KMC
3. Or Equal

B. Acceptable Manufacturers for BACnet Gateways:

1. Control Solutions
2. Or Equal

C. Acceptable Manufacturers for BACnet Integrators:

1. Tridium
2. Or Equal

3. BACNET INTEROPERABILITY BUILDING BLOCKS

A. In addition to the minimum required BACnet Interoperability Building Blocks (BIBBS) per each device profile set forth by ASHRAE, the following shall also be required:

1. B-BC:

a. DS-COV-A/B
b. DS-M-A
c. DS-V-A
d. AE-VN-A
e. AE-VM-A
f. SCHED-VM-A
g. T-ATR-A
h. T-V-A
i. DM-TS-A
j. DM-R-B
k. DM-OCD-B
l. DM-ANM-A
m. DM-ADM-A
n. DM-ATS-A
o. DM-MTS-A

2. B-GW:

a. DS-RPM-B
b. DS-WPM-B
c. DS-COV-B
d. DM-RD-B

4. BRIDGES

A. Bridges are not approved for installation on the Owner's network.

5. ROUTERS

   A. Routers are not approved for installation on the Owner's network by any party other than the Owner.

   B. Wireless routing devices are not approved for use on the Owner's network.

   C. Any routers temporarily installed for remote access to the devices as part of this project must be approved by the Owner prior to installation. While installed, no device connected to or accessible from the router will be on the Owner's network.

6. GATEWAYS

   A. Gateways may be installed for translation of communication protocols to BACnet/IP.

   B. Gateways shall only be approved where BACnet Building Controllers or Integrators are not an economical or viable option.

   C. Gateways installed for permanent use shall adhere to following:

      1. BTL and UL Listed

      2. Configurable via web interface

         a. No additional software will be required to configure the gateway

      3. Capable of DHCP configuration

      4. Rated for operation at 32° F to 120° F

      5. DIN rail mountable

7. INTEGRATORS

   A. Integrators shall be approved for installation on the Owner's network.

   B. Integrators shall be configured as BACnet devices. Data between multiple integrators must use the BACnet protocol, unless otherwise specified by the Owner.

   C. Trend and scheduling objects shall be configurable and data store storage available in any integrator.

   D. Integrators may be used as an input monitoring device so long as IO modules for monitoring only if they are installed for primary use as an integrator and is more economical than another device installation.

   E. Integrators shall also adhere to the following:

      1. Capable of acting as a protocol gateway between network supervisor and field devices.

2. Capable of acting as a BACnet Broadcast Management Device (BBMD).
3. Be modular in nature to allow for future capacity expansion. This includes data storage capacity as well as necessary IO modules for monitoring purposes.
4. Integrators with point count or device count limitations shall be sized for total point and/or device count plus 10% capacity.
5. Shall include an uninterruptible real time clock. This clock shall keep time of day, day of week, month, and year information. The Integrator shall also be capable of syncing its time with the building automation server, and sync time to all field level controller.
6. BTL and UL listed.
7. DIN rail mountable.
8. Minimum of 4GB of flash storage space.
9. Support SSL and TLS encryption.

PART 3 – EXECUTION

1. NETWORK COMMUNICATION REQUIREMENTS
   A. For network communication requirements reference section *25 12 00 Integrated Automation Network Configuration*
2. GENERAL INSTALLATION
   A. For installation requirements, reference section *25 36 00 Integrated Automated Instrumentation and Terminal Devices for HVAC.*
3. INTEGRATORS
   A. Any new Integrator installed on the Owner's network shall pass all data as BACnet objects over the Owner's BMS network. No data will be shared as any other communication protocol unless approved by the Owner for specific applications.
   B. Integrators shall be used as gateways for devices that are not capable of trending or scheduling and where no BACnet Building Controller is available.
   C. Integrators shall be furnished with an uninterruptable power supply if one did not previously exist. This uninterruptible power supply shall only

supply emergency power for their respective controller and must adhere to the following:

a. DIN rail mounted within the same controls enclosure

b. Emergency power for a minimum of one hour

c. Outputs for UPS alarms and status

D. For network setup and configuration reference section *25 12 00 Integrated Automation Network Configuration*

****END OF SECTION****

Section Number | Title

25 12 00 INTEGRATED AUTOMATION NETWORK CONFIGURATION

PART 1 – GENERAL

1. SUMMARY
   A. This section defines the networking protocols to be utilized by the Owner's building automation network.
   B. Related Sections:
      1. *25 00 00 Integrated Automation*
      2. *25 11 00 Integrated Automation Network Devices*
2. REFERENCES
   A. Refer to *25 00 00 Integrated Automation.*
3. DEFINITIONS
   A. Refer to *25 00 00 Integrated Automation.*
   B. System Description
   C. Refer to *25 00 00 Integrated Automation*.
4. SUBMITTALS
   A. Refer to *25 00 00 Integrated Automation.*
5. QUALITY ASSURANCE
   A. Coordinate all related network infrastructure changes with the Owner. Any changes to network components or infrastructure without prior authorization from the Owner is not permitted.
   B. Network configurations for IP devices are assigned by the Owner. Any devices not matching the approved network configurations shall not be allowed on the Owner's network.
   C. All new BACnet devices must be BTL listed unless otherwise approved by the Owner.
   D. All Modbus devices shall be a member of the Modbus Organization and shall comply with all Modicon protocol standards.
   E. BBMD devices shall only be setup on the Owner's network with the Owner's approval.
   F. Refer to *25 00 00 Integrated Automation* for additional quality assurance requirements.

6. WARRANTY

   A. Refer to *25 00 00 Integrated Automation.*

PART 2 – PRODUCTS

N/A

PART 3 – EXECUTION

1. SITE WIDE GENERAL NETWORK COMMUNICATION REQUIREMENTS

   A. All network activities shall be coordinated with the Owner prior to any work performed.

   B. Field devices shall be integrated to the enterprise level utilizing the BACnet/IP protocol.

   C. Integrators shall convert all serial communications to BACnet/IP for integration into network supervisors.

   D. Any field devices with a separate enterprise level that cannot be translated to BACnet/IP shall be capable of data sharing via an XML data transfer process.

   E. Portions of the Owner's building management system lie on a local VLAN. These existing legacy components shall remain as is unless otherwise specified by the Owner.

   F. New building management TCP/IP devices shall utilize DHCP. Static IP devices are not permitted unless otherwise specified by the Owner.

   G. For IP devices, the Owner shall provide network configuration properties. The Controls Contractor shall configure and assign the following:

      1. Each sub network ID shall be the IP address and the number of routed networks on the device as a single digit-number.

      2. Devices shall be given unique sequential instance IDs from instance IDs with no skipped values.

      3. Devices shall be given device ID that matches the network ID on which it resides followed by the device instance ID as a two digit-number.

H. The below protocols are permitted on the Owner's building management network:

1. BACnet

a. BACnet/IP is permitted everywhere.

b. BACnet MS/TP is permitted in limited capacity. See section 3.2 for details.

2. Modbus

a. Modbus TCP

b. Modbus RTU in limited capacity. See section 3.2 for details.

3. TCP/IP

a. Tridium FOX/FOXS

4. HTTP/HTTPS

2. CONTROL AND MONITORING OF NETWORK COMMUNICATION

A. Any new IP device shall have their ethernet protocol disabled prior to installation onto the Owner's building management network.

B. New field devices shall be BACnet/IP, unless building design constraints deem BACnet/IP as an ineffective design option.

C. For equipment where BACnet/IP is not an effective option, BACnet MS/TP may be permitted under special circumstances upon approval by the Owner. These circumstances can be, but are not limited to:

1. Where it makes sense to use a single BACnet/IP controller on a major piece of equipment to route data from multiple minor devices, such as VAV boxes.

2. To integrate 3rd party devices that do not support BACnet/IP, such as VFDs or packaged roof top units.

D. New metering devices shall be BACnet/IP. Where BACnet/IP is unavailable for metering devices, Modbus TCP is the acceptable alternative. Metering devices shall not utilize serial RS-485 communication protocols unless otherwise specified by the Owner.

E. IP device ports shall be configured as follows:

1. IP port 1 shall be configured to the Owner approved IP device configuration parameters.

2. Where available, IP port 2 shall be configured to a generic IP address specified by the Owner for direct local connection to the device.

3. Any additional IP ports shall be disabled.

****END OF SECTION****

Section Number | Title

25 14 00 INTEGRATED AUTOMATION FIELD DEVICES

PART 1 – GENERAL

1. SUMMARY
   A. This section defines the requirements for field level controllers for the Owner's building management system.
   B. Related Sections:
      1. *25 00 00 Integrated Automation*
      2. *25 11 00 Integrated Automation Network Devices*
      3. *25 12 00 Integrated Automation Network Configuration*
2. REFERENCES
   A. Refer to *25 00 00 Integrated Automation.*
3. DEFINITIONS
   A. Refer to *25 00 00 Integrated Automation.*
4. SYSTEM DESCRIPTION
   A. Refer to *25 00 00 Integrated Automation.*
5. SUBMITTALS
   A. Refer to *25 00 00 Integrated Automation.*
6. QUALITY ASSURANCE
   A. Multiple controllers shall not be networked together to control a single piece of equipment.
   B. Controller performance tests on existing field controllers shall be performed after each device has been integrated into the building management system. The minimum required functional tests shall be:
      1. Object Command Test: Test the time between an operator command of a BACnet proxy point via the network integrator or GUI in order to change the value at the field device. The maximum allowable time for change of value at the field device is less than or equal to 5 seconds.
      2. Object Scan Test: Test the change of state or value of an integrated BACnet proxy point via the network integrator or GUI in order to confirm the value shown at integrator or GUI will have been current within the previous 10 seconds.

3. Alarm Response Time Test: Test the maximum time from when an object goes into alarm and to when it is annunciated at the workstation. The maximum allowable time shall not exceed 10 seconds for a Level 1 alarm, 20 seconds for alarm levels 2 and 3, and 30 seconds for alarm level 4.

C. BACnet devices must be BTL listed unless otherwise specified by the Owner.

D. All Modbus devices must be a member of the Modbus Organization.

E. Devices shall be able to adhere to the following:

1. Store setpoints and schedules in non-volatile memory.

2. Support energy saving conservation measures with no additional controller hardware.

3. Be configured as stand-alone system control in the event of a network failure.

4. Can manipulate sequences, timers, setpoints, etc. as required to meet or exceed the design intent of the equipment served.

F. Refer to *25 00 00 Integrated Automation* for general quality assurance requirements.

7. WARRANTY

A. Refer to *25 00 00 Integrated Automation*.

8. DELIVERY, STORAGE, AND HANDLING

A. Products shall be stored according to manufacturer's recommendations.

B. Products shall be stored in their original manufacturers packaging until installation.

PART 2 – PRODUCTS

1. GENERAL PRODUCT REQUIREMENTS

A. BACnet IP shall be the default communication protocol for all new field controllers. Where building constraints prevent the use of BACnet/IP, BACnet MS/TP is the preferred alternative communication protocol for field controllers.

B. New Chillers, Boilers, Packaged Rooftop Units, and Variable Frequency Drives shall include network integration cards for monitoring and control.

Each integration card must utilize the BACnet communication protocol unless otherwise specified by the Owner.

C. If BACnet MS/TP is utilized, new field controllers shall come with built in communication end of line resistors.

D. Additional field controller requirements include the following:

1. Shall have a fusible overcurrent protection. Fuse must be replaceable.
2. Shall not be limited in their ability to communicate with a specific brand or model.
3. Shall have a minimum operating temperature range between 32° F and 122° F.
4. Shall withstand a humidity range of 0% to 90%, non-condensing.
5. Shall have diagnostic LEDs for communication and power.
6. Shall remain functional with any BACnet system without license and/or maintenance costs.
7. Capable of programming and configuration from a remote workstation.
8. Shall allow for complete communication for all building automation system field devices and any integrated 3rd party devices.
9. Shall include an uninterruptible real time clock. This clock shall keep time of day, day of week, month, and year information. The field controller shall also be capable of syncing its time with the building automation system.

2. MANUFACTURED UNITS

A. Acceptable Manufacturers:

1. Acuity Brands/Distech Controls.
2. Or Equal

3. BACNET INTEROPERABILITY BUILDING BLOCKS

A. In addition to the minimum required BACnet Interoperability Building Blocks (BIBBS) per each device profile set forth by ASHRAE, the following shall also be required:

1. B-BC:

a. DS-COV-A/B

b. T-VMT-E-B

c. DM-OCD-B

2. B-AAC:
   a. DS-COV-B
   b. AE-ESUM-B
3. B-ASC:
   a. DS-RPM-B
   b. DS-WPM-B
   c. DS-COV-B
   d. SCHED-I-B
   e. DM-RD-B
   f. DM-TS-B
4. B-SA
   a. DS-RPM-B
   b. DS-WPM-B
   c. DS-COV-B
   d. DM-RD-B
   e. DM-TS-B
5. B-SS:
   a. DS-RPM-B
   b. DS-WPM-B
   c. DM-TS-B

4. PROGRAMMABLE DEVICES

A. All physical and electrical requirements are referenced in section *25 36 00 Instrumentation and Terminal Devices for HVAC.*

B. Programmable controllers shall be BACnet BTL listed. Controllers shall support local BACnet calendars, scheduling objects, trend objects, and notification classes.

C. Devices listed with BACnet profile B-BC shall be used for any field equipment that consists of multiple pieces of sub equipment Including, but not limited to,

1. Terminal unit controls

2. VFDs
3. Integrated communication cards

D. Devices listed with BACnet profile B-AAC may be used with all other field equipment that does meet the requirement for B-BC devices and B-BC devices are not available or economical.

E. Devices listed with BACnet profile B-ASC controllers may be permitted for use so long as it meets all of the other criteria required for a programmable controller and neither B-BC nor B-AAC devices are an economical option.

F. All non-native BACnet controllers must be approved by the Owner.

G. IP devices shall be set-up as DHCP devices and must have pre-approved network configuration from the Owner, following procedure documented in division section *25 00 00 Integrated Automation.*

H. All device addressing requirements are documented in division section *25 12 00 Integrated Automation Network Configuration.*

I. Multiple field controllers shall not be used to control a single piece of equipment where critical sensor data must be sent over the building management network for adequate equipment control. The Controls Contractor must instead specify field controllers capable of expandable input/output modules.

J. Any building management system hardware installed on any Owner site shall not be limited in their ability to communicate with a specific brand or model.

K. Controllers shall be programmed to function as standalone equipment in the event of a network failure. This includes fallback values setpoints, as well as continued trending and notifications.

5. NON-PROGRAMMABLE DEVICES

A. Any devices specified shall have any required trending and scheduling setup as BACnet objects internal to the non-programmable device.

B. Any non-programmable IP devices that are not capable of trending and scheduling internally shall require an Integration Contractor to setup trending scheduling on the BMS supervisor.

C. Any non-programmable serial devices that are not capable of trending and scheduling internally shall require a hard-wired integrator specified as part of the project to configure all trending and scheduling.

D. Any existing integration devices can only be reused if approved by the Owner prior to project design approval.

PART 3 – EXECUTION

1. INSTALLATION

   A. Existing field controllers shall remain as they are at the time of the project and shall be integrated into the BMS without loss of functionality at the Owner's request.

   B. If an existing field controller is unable to be integrated into the BMS due to loss of functionality, the specific losses in function shall be documented and a replacement field controller shall be quoted by the controls contractor and presented to the Owner for evaluation. The Owner shall then determine how to proceed with the field controller in question.

   C. The Controls Contractor shall provide the new field controllers, and all required miscellaneous hardware for system monitoring and control of equipment.

   D. New field controller location and connection to the Owner's building management system must be approved by Owner prior to any work performed.

   E. All device addressing shall be setup as indicated in section *25 12 00 Integrated Automation Network Configuration*.

   F. Existing controllers shall not be readdressed, unless otherwise specified by the Owner. The Controls Contractor shall be responsible for verifying new device IDs and network numbers do not conflict with existing BMS architecture.

   G. Provide controllers with expanded input/output capabilities and add additional input and output modules as required to meet point list requirements. Total required inputs and outputs must be approved by the Owner prior to any work performed.

   H. Device IP address and HVAC network MAC Address shall be labeled on the side of the devices prior to substantial completion utilizing a label maker.

2. SCHEDULES

   A. Scheduling as defined in this section shall be completed by Controls Contractor or documented to proper completion by Integration Contractor as defined in section *25 00 00 Integrated Automation.*

   B. Schedules shall be set up as BACnet Schedule Objects and shall follow the Owner's Object Naming Standard.

   C. Devices that support BACnet schedule objects must be configured directly in the device.

D. Devices that do not support BACnet schedule objects must be configured in the IP device routing the device's data.

E. Scheduling shall be set up per the sequence of operations.

F. Schedule programming shall have a BACnet object indicating which schedule is active in the device.

3. TRENDING

A. Trending as defined in this section shall be completed by Controls Contractor or documented to proper completion by Integration Contractor as defined in section *25 00 00 Integrated Automation.*

B. Devices that support BACnet trend objects must be configured directly in the device.

C. Devices that do not support BACnet trend objects must have trends configured in a network controller routing the device's data.

D. Devices must be specified to have enough memory to store at minimum 72 hours of trends without losing data.

E. Devices with trending capabilities shall be setup to export trends as BACnet objects directly to the Supervisor.

F. Trend objects shall be named to match the Owner's object naming standard. This shall be the object name with the trend identification "Tr" at the end of the name to provide a unique object name.

G. Minimum trending shall be set up as follows:

1. Hardwired and calculated (e.g. calculated supply air temp reset setpoint) analog objects and shall be trended at 5-minute intervals.

2. Hardwired Boolean objects shall be trended as COV.

3. Virtual Boolean and enumerated objects that indicate status, command, mode, etc. shall be trended as COV.

4. Writable manual setpoints (e.g. occupied room temp setpoint) shall be trended as COV.

H. Trend setup and discovery into the Supervisor shall be completed by Integration Contractor and is referenced in section *25 15 00 Integrated Automation Software.*

I. *Refer to Appendix for metering and other trend name standards.*

4. NOTIFICATIONS AND ALARMING

   A. Notifications and alarms as defined in this section shall be completed by Controls Contractor or documented to proper completion by Integration Contractor as defined in section *25 00 00 Integrated Automation.*

   B. Notification classes shall be broken up by building at the Niagara N4 Supervisor with individual building alarm consoles and a single consolidated alarm console for the entire building portfolio.

   C. Devices that support BACnet notification classes and BACnet alarm objects must have all notification classes and BACnet alarm objects programmed internally.

   D. Devices that do not support BACnet notification classes must have alarming/notification configured in the IP device routing the device's data.

   E. Minimum notification parameters shall be the following:

      1. Life Safety, Level 1 – Alarms under this notification class shall be sent out to Operations and Maintenance personnel 24 hours a day, 7 days a week via SMS text and email and shall show up on a GUI alarming console.

      2. Critical, Level 2 – Alarms under this notification class shall be sent out to Operations and Maintenance personnel 24 hours a day, 7 days a week via SMS text and email and shall show up on a GUI alarming console.

      3. Urgent, Level 3 – Alarms under this notification class shall be sent out to Operations and Maintenance during normal operating hours via SMS text and email and shall show up on a GUI alarming console.

      4. Normal, Level 4 – Alarms under this notification class shall show up on a GUI alarming console.

   F. Alarms shall be configurable as latching or non-latching. Latching alarms require the operator to acknowledge the alarm condition and manually reset the alarm before the device will return to normal operation. Non latching alarms do not require acknowledgement and shall automatically reset the alarm condition. The following are the latching requirements for each level of alarm:

      1. Level 1: Latching

      2. Level 2: Latching

      3. Level 3: Non-Latching

      4. Level 4: Non-Latching

G. Operators with the appropriate security clearance shall have the ability to put any device into and out of Maintenance Mode.

1. While in Maintenance Mode, all alarms associated with the device will be suppressed, except for Life Safety alarms.
2. When a device is put into Maintenance Mode, a Level 3 level alarm will be generated at a scheduled time determined by the Owner to remind the operators that the device is still in Maintenance Mode.
3. See section *25 15 00 Integrated Automated Software* for security clearances for user.

H. All alarms shall have an adjustable delay that prevents the alarm from triggering unless the alarm condition has been true for greater than or equal to the time delay. The initial time delays shall be the following unless indicated otherwise in the sequence of operations:

1. Level 1: 1 second
2. Level 2: 10 seconds
3. Level 3: 1 minute
4. Level 4: 5 minutes

I. All alarms shall have an adjustable time-based hysteresis to exit the alarm condition. The alarm shall not return to normal until the alarm conditions have ceased for the duration of the hysteresis. The initial time-based hysteresis value shall be 5 seconds for all alarms.

J. All analog alarms shall have an adjustable percent-of-limit-based hysteresis the alarmed variable required to exit the alarm condition. Alarm conditions have ceased when the alarmed variable is below the triggering threshold by the amount of the hysteresis. The initial percent-of-limit-based hysteresis value shall be noted in the Sequences of Operation.

****END OF SECTION****

Section Number | Title

25 15 00 INTEGRATED AUTOMATION SOFTWARE

PART 1 – GENERAL

1. SUMMARY
   A. This section defines the requirements for any supervisory software or software setup required to read and write data across the network, store and archive data, and display data in a graphical user interface.
   B. Related Sections:
      1. *25 00 00 Integrated Automation*
      2. *25 14 00 Integrated Automation Field Devices*
2. REFERENCES
   A. Refer to *25 00 00 Integrated Automation.*
3. ACRONYMS
   A. Refer to *25 00 00 Integrated Automation.*
4. DEFINITIONS
   A. Refer to *25 00 00 Integrated Automation*.
5. SYSTEM DESCRIPTION
   A. Refer to *25 00 00 Integrated Automation*.
6. SUBMITTALS
   A. Refer to *25 00 00 Integrated Automation.*
7. QUALITY ASSURANCE
   A. SaaS and Cloud based applications must adhere to the following national and international standards:
      1. ISO/IEC 27001
      2. ISO/IEC 27017
8. WARRANTY
   A. Refer to *25 00 00 Integrated Automation.*

PART 2 – PRODUCTS

1. GENERAL REQUIREMENTS

   A. Any licensing or service level agreements must adhere to the following:

      1. The Owner is listed as the Owner of the software.

      2. Open to third-party services and applications, and not limited to a specific brand, contractor, or manufacturer.

   B. Software purchased by the Owner for programming, configuration, or maintenance of devices on BMS shall not prevent the system from fully functioning as designed upon expiration of its license.

   C. For any proprietary systems that do not have a BACnet/IP option for communication between Field Devices and BMS Supervisor, supervisory software must be capable of XML data transfer to and from the BMS Supervisor.

2. SAAS AND CLOUD BASED APPLICATIONS/STORAGE

   A. All information shall be available for export by the Owner to a standard usable file format at any time.

   B. Any data stored at rest or in transit between the cloud service and the Owner shall be encrypted.

   C. Any SaaS must have a dedicated instance for the Owner. Public infrastructure is prohibited.

   D. Detailed audit logs must also be available for the Owner to review.

   E. Applications shall not have any licensing and shall only have service level agreements.

   F. Any installed routers for data transfer to off-site service must be approved by the Owner prior to approval.

   G. The ability to increase storage space on any application must be available to the Owner at any time during the SLA.

   H. If option is available, the storage location for off-site storage must be the closest in physical location to the Owner.

PART 3 – EXECUTION

1. NETWORK COMMUNICATION REQUIREMENTS

   A. For network requirements of field devices and data configuration, see section *25 14 00 Integrated Automation Field Devices.*

2. SAAS/CLOUD PRODUCTS

   A. SLA agreements shall be signed by the Owner and can be canceled by the Owner at any time with no penalties or fees.

   B. The Owner shall have full access rights available to customers for SaaS or Cloud service.

   C. Any product installation must adhere to the following sections:

      1. *25 10 00 Network Equipment*

      2. *25 12 00 Network Configuration*

   D. For internet connections for data transfers, the Owner must be supplied with the HTTPS address to be placed on the ALLOWED List.

   E. Any services that shall need to be run on the server shall need to be pre-approved by the Owner, and proper access shall need to be granted to the approved Controls Contractor and Integration Contractor to set up their services.

3. SUPERVISORY SOFTWARE

   A. SMA agreements shall not prevent the system from fully functioning as designed upon expiration of its license.

   B. Supervisory software must be installed by Controls Contractor or the Integration Contractor by a licensed representative of the product.

   C. Software being installed must be the newest version available, and must be updated to the newest available version as stated in section *25 00 00 Integrated Automation*.

   D. Any additional software required for configuration or maintenance must also be installed on the same server as the supervisory software.

   E. Install files, updates, and patches must be stored on the server that they are installed.

   F. The Controls Contractor and the Integration Contractor are responsible for coordinating internet access requirements for software updates and remote support with the Owner prior to the start of the project.

   G. Owner shall have administration account created in any installed supervisory software prior to project close-out, and all generic and default accounts shall be deactivated or removed.

4. DEVICE CONFIGURATION/PROGRAMMING SOFTWARE

   A. Programming languages used for devices on BMS are limited to block style programming. Line code and ladder logic programming are not acceptable unless otherwise directed by the Owner.

   B. Any software required for field device programming, configuration, or maintenance that the Owner does not currently own shall be purchased and installed on the Owner's server as part of the project.

   C. If an obsolete version of software or firmware is utilized by devices on the Owner's BMS and an updated version is required for the project, it is the responsibility of the Controls Contractor and/or Integration Contractor to verify the new version does not cause any adverse effects to BMS functionality or existing devices. If the potential for adverse effects is unavoidable, both software versions shall be installed in parallel if existing devices cannot be upgraded as part of project.

   D. If parallel versions of software must be installed, step-by-step documentation for simultaneous use of the parallel software shall be provided by the Contractor responsible for installing the new software. This document must be presented to the Owner at close-out and demonstrated in the Contractor provided training session.

5. INTEGRATION

   A. Integration of any device into the BMS shall be completed by the Integration Contractor.

   B. At a minimum, the BMS shall be able to communicate through data lines, with the existing Niagara N4 system for monitoring and control.

   C. Trend data shall be discovered into the Niagara N4 Supervisor as BACnet trend objects and shall be imported every 30 minutes.

      1. All trend objects shall be tagged at the Niagara N4 server for grouping purposes. Trends shall be grouped in the following manner:

         a. Building

         b. Equipment

         c. Sub Equipment

      2. New trend objects may be generated for BACnet objects not currently trended at the Owner's discretion. Any new trend objects that are generated as part of this project will be created in Niagara N4.

      3. Trended objects stored on the Niagara N4 trend repository shall also be exported to the Owner's SQL trend repository via Niagara N4. These

trends shall be exported once daily to the SQL server during hours of low network traffic.

D. Alarms shall be discovered into the Supervisor as BACnet alarm objects.

1. If a BACnet object used for alarm notification does not utilize a BACnet alarm object, the BACnet object will be alarmed at the Niagara N4 level utilizing the Niagara alarm extensions and shall be setup to follow the alarming and notification classes requirements noted in section *25 14 00*.

a. If recreation of alarm condition logic is required for the alarm to function properly in Niagara N4, then the alarm shall not be integrated as part of the project.

E. Any device or object names that cannot be renamed to match the Owner's Object Naming Standard must be documented as stated in section *25 00 00 Integrated Automation.*

6. GRAPHICAL USER INTERFACE

A. General Requirements

1. New graphics shall be created in the Owner's Niagara N4 supervisor.

2. All Niagara N4 px pages, chart builders, etc. shall utilize HTML 5. Java web applet views (Ax views) are not permitted.

3. Graphical pages shall be stored on the supervisor in an orderly manner based on building, equipment type, and equipment name in order to be easily identified for future editing.

4. Graphical representations for newly installed control devices shall be schematically accurate and reflect the physical layout of the equipment. All physical and virtual points relevant to system operation shall be displayed on these graphics.

5. System and sub system equipment names and zones served shall be clearly identified on their respective graphical screens. Equipment names shall match identifiers noted on construction drawings.

6. System and sub system main graphics shall include key items only (I/O, effective setpoints, etc.). All other relevant setpoints shall be available on a supplemental setpoint graphic, which is accessible from a direct hyperlink in the main system graphic.

7. Verbose names shall be included for each point on all graphics. These names shall either be next to or on top of the value it's representing. Popups are not allowed.

8. Indicate all adjustable setpoints and setpoint high and low limits for automatically reset setpoints, on the applicable system schematic graphic or, if space does not allow, on a supplemental linked or tabbed setpoint screen.
9. For all systems and sub systems with runtime alarms specified, show on graphic adjacent to equipment the current runtime, alarm setpoint (adjustable), alarm light, date of last runtime counter reset, and alarm reset/acknowledge button which resets the runtime counter.
10. For all systems with lead/lag or lead/standby operation specified, show on graphic adjacent to equipment the current lead/lag order and manual buttons or switches to allow manual lead switching by the operator.
11. For all controlled points used in control loops, show the setpoint adjacent to the current value of the controlled point.
12. I/O objects on system and sub system graphics shall be shown in approximately the same location as their physical installation location.
13. Show local weather conditions in the header of every graphic.
14. Existing equipment slated for integrated from the Alerton system into Niagara N4 shall be generated to emulate layout and functionality of the existing Alerton graphical user interface.
15. Graphical displays shall be 1280x1024 pixels or denser and shall automatically resize to fit the user's screen.
16. Graphics shall allow for unique user IDs and passwords to be setup with different access rights and landing pages. Groups shall also be established to assign user IDs to with different access rights. A minimum of four groups will be established with the minimum access listed below.
    a. Read Only access to graphics and trends.
    b. Building Manager – Ability to override space temperatures, view alarms, view and setup trends, and set schedules.
    c. Operator – Building manager access plus the ability setup and acknowledge alarms, and to temporarily (no permanent) override all points.
    d. Administrator – Full access.

17. A tiered navigation tree shall be generated for each building. Navigation tree shall generally be laid out in the following manner:
    a. Building
    b. System
    c. Subsystem or Equipment Name
    d. Device Objects, Trends Views, and Schedules
18. All system and sub system graphical pages shall contain a user editable text block that shall be used to convey updates relevant to that specific system or sub system.

B. Link Requirements

1. Each graphical page will have a direct link back to their respective building's home page located in the graphic header.
2. Hyperlinks between graphical page shall allow the user to navigate screens in a logical manner without requiring the user to return to the main landing page.
3. Informational links for the following documents shall be created for each system and sub system in each building. Links to these items shall be accessible from their respective system or sub system graphic.
    a. PDF copies of the mechanical and controls as-builts with sequences of operation.
    b. PDF copies of O&M and submittal information for all associated devices.
4. Each system and sub system shall have direct links to trend views that show relevant information. It shall be the responsibility of the Integration Contractor to coordinate with the Owner to determine what trends are required on the trend views.

C. Object Requirements

1. All relevant objects for monitoring and setpoint control for each piece of equipment shall be displayed with the appropriate engineering units. Each engineering unit will also be setup with proper precision to ensure values are easily read by the user. Unit precision shall be as follows:
    a. Temperature values shall be set to one decimal place.
    b. Percentage values shall be set to zero decimal places.
    c. Building pressure in in/WC shall be set to three decimal places.

d. Static pressure in in/WC shall be set to two decimal places.

e. Pressure in psi shall be a minimum of one decimal place, depending on application.

2. All setpoints shall be made available on the graphics for editing by the user.

3. All writable objects shall have an override feature. Override capabilities of each user shall be determined by their system security level.

4. Administrator users shall have the ability to permanently override an object at the emergency priority level.

5. Non-emergency overrides shall have a maximum override time of 24 hours. Override duration shall be adjustable by an Administrator level user.

6. When an object is commanded to an override state, the user shall be presented with a dialog box showing the following:

   a. Numeric Objects shall allow you to enter the override value and release the object from the override state.

   b. Binary and Enumerated Objects shall allow you select an override value from a dropdown list and release the object from the override state.

   c. A dialog box shall be opened upon override of an object for the user to input an override explanation.

   d. The override value shall only be sent to the controller once the dialog box has been closed. The dialog box shall not be allowed to close until an override explanation has been entered.

7. All overridden values shall be clearly identified on their respective graphical screens.

8. Override and offline device summary tables shall be created for each building. The building level summary tables shall be accessible from the building's landing page and should only contain data from that building.

9. Override and offline device summary table data from each building shall be consolidated and presented as a site wide summary table on the overall site landing page.

10. Values and symbols representing equipment shall be able to change color or become animated based on status.
    a. Values representing temperatures that have an associated setpoint shall change their background color based on how far from setpoint the temperature value is. The background color gradient shall change from orange when the temperature is above setpoint to blue when the temperature is below setpoint.
    b. Binary objects shall show up as grey when their values are “false” and green when their values are “true”.
    c. Objects with associated alarms shall change their background color to red when the object is in alarm.
    d. Objects shall change their background color to purple when the object is overridden.

D. Individual Graphical Requirements
    1. Site homepage:
        a. Background shall be a campus map, approximately to scale. Include links to each building, central plant, etc.
        b. Buildings that are integrated into Niagara N4 with completed graphics shall be identified by highlighting when the mouse hovers over the building.
        c. Site homepage shall have a visible alarm console showing a consolidated view of all alarms across all buildings on the site.
        d. Site homepage shall have an override summary that will show the user the current list of overridden objects and their associated equipment across all buildings on the site.
    2. Building homepage:
        a. Background shall be a building footprint, approximately to scale, oriented as shown on the campus homepage. Include links to each floor and mechanical room/area, and to summary graphics described below. Include real-time site utility data such as building electrical demand, domestic cold-water flow, and recirculated water demand shown roughly on the map where the utilities connected to the site.
        b. Building homepage shall also have a visible alarm console showing all alarms relevant to the building and an override summary that will show the user the current list of overridden objects and their associated equipment within the building.

c. Critical items from major equipment shall be included on the building home page.

3. Floorplans:

a. The building drawings and/or building lifts will be made available to the Contractor (in AutoCAD format if available) upon request for use in developing floor plans. However, the Owner does not guarantee the suitability of these drawings for the Contractor's purpose.

b. Separate floorplan graphics shall be generated for HVAC zones and lighting zones.

i. The terminal units with individual controllers, ductwork downstream of the terminal units, thermostats, and room data (Temperature/CO2/Humidity as applicable) shall be shown in their accurate locations. The terminal units will be linked to the unit's control page.

c. Floorplan graphics shall show heating and cooling zones (or lighting zones) throughout the buildings. Each zone will be clearly outlined and provide a range of colors that provide a visual display of temperature relative to their respective setpoints. The colors shall be updated dynamically as a zone's actual comfort condition changes. In each zone, clicking on either the zone outline or the zone name/temperature value shall link directly to the terminal equipment.

d. If multiple floorplans are necessary to show all areas, provide a graphic building key plan. Use elevation views or plan views as necessary to graphically indicate the location of all larger scale floorplans. Link graphic building key plan to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen to the building key plan and to each of the other graphic floor plan screens.

e. Meter locations shall be shown on the floorplans.

4. Summary Pages

a. Provide summary graphics that show key variables listed in columns for like equipment. Systems noted in the summary pages will have a direct hyperlink to their respective MEP graphic.

b. Sub system summary shall only contain equipment served by the same system.

c. For large systems and sub systems that are unable to fit on a single page, split the equipment up onto separate pages with direct hyperlinks to and from each summary page.

d. A direct hyperlink to a sub system summary page shall be located near the parent

system on the major system summary graphic.

e. Summary graphics shall be broken up by equipment type.

f. Single Zone Air Handling Units:

i. Equipment Name

ii. Zone Served

iii. Operating Mode

iv. Zone Temperature

v. Effective Zone Temperature Setpoint or Effective Heating/Cooling Setpoints

vi. Supply/Exhaust Fan Command/Speed/Status

vii. Coil Valve Position or DX Status

viii. Supply Air Temperature

ix. Effective Supply Air Temperature Setpoint

x. Outdoor Air/Return Air Damper Position

xi. Trim and Respond Total Call

g. Multi Zone Air Handling Units:

i. Equipment Name

ii. Zone(s) Served

iii. Operating Mode

iv. Duct Static Pressure

v. Effective Duct Static Pressure Setpoint

vi. Supply/Exhaust Fan Command/Speed/Status

vii. Coil Valve Position or DX Status

viii. Supply Air Temperature

ix. Effective Supply Air Temperature Setpoint

x. Outdoor Air/Return Air Damper Position

xi. Trim and Respond Total Calls

h. Constant Air/Variable Air Volume Boxes:

i. Equipment Name

ii. Zone(s) Served

iii. Operating Mode

iv. Zone Temperature

v. Effective Zone Temperature Setpoint or Effective Heating/Cooling Setpoints

vi. Hot Water Valve Position (where applicable)

vii. Discharge Air Temperature (where applicable)

viii. Discharge Air Temperature Setpoint (where applicable)

ix. CO2 (where applicable)

x. CO2 Setpoint (where applicable)

xi. Airflow

xii. Active Airflow Setpoint

xiii. Trim and Respond Total Calls and Importance Multiplier

i. Fan Coil Unit Summary:

i. Equipment Name

ii. Zone(s) Served

iii. Operating Mode

iv. Zone Temperature

v. Effective Zone Temperature Setpoint or Effective Heating/Cooling Setpoints

vi. Hot Water Valve Position (where applicable)

vii. Discharge Air Temperature (where applicable)

viii. Discharge Air Temperature Setpoint (where applicable)

ix. CO2 (where applicable)

x. CO2 Setpoint (where applicable)

j. Exhaust Fan Summary:

i. Equipment Name

ii. Zone(s) Served

iii. Fan Status

iv. Airflow (where applicable)

k. Electrical Meter Summary:

i. Meter Name

ii. Voltage (all legs)

iii. Current (all phases)

iv. Total Real Power

v. Total Kilowatt Hours

l. Water Meter Summary:

i. Meter Name

ii. Flow Rate

iii. Totalized Flow

m. BTU Meter Summary:

i. Meter Name

ii. Flow Rate

iii. Energy Rate

iv. Supply and Return Temperature

****END OF SECTION****

Section Number | Title

25 36 00 INTEGRATED AUTOMATION INSTRUMENTATION AND TERMINAL DEVICES

PART 1 – GENERAL

1. SUMMARY
   A. Associated hardware shall be defined herein as sensors (e.g. temperature probe), and control devices (e.g. actuators).
   B. Related Requirements:
      1. *23 08 00 Commissioning of Mechanical Systems* (HVAC systems and controls)
         a. Commissioning requirements for this section are contained in Section *23 08 00*.
2. REFERENCES
   A. Refer to *25 00 00 Integrated Automation and 23 08 00 Commissioning of Mechanical Systems.*
3. DEFINITIONS
   A. Refer to *25 00 00 Integrated Automation.*
4. SYSTEM DESCRIPTION
   A. Refer to *25 00 00 Integrated Automation.*
5. SUBMITTALS
   A. Refer to *25 00 00 Integrated Automation.*

PART 2 – PRODUCTS

1. CONTROLLERS
   A. Refer to *25 11 00 Integrated Automation Network Devices* and *25 14 00 Integrated Automation Field Devices.*
2. ELECTRICAL WIRING AND DEVICES
   A. All electrical work shall comply with Division 26 requirements, all building electrical codes and NAU Technical Standards.

B. Communication Wiring:

1. The Controls Contractor shall provide all communication wiring between all Network Devices, Routers, Protocol Translators, and Field Devices.

2. IP Protocol devices shall use Category 5 or Category 6 cable that meet requirements stated in EIA/TIA 568. Network wiring shall not be spliced together and shall be ran separately from high voltage wiring.

C. Input/Output Signal Wires:

1. All signal wires from field devices to sensors and control devices shall utilize shielded, twisted pair wire. Wire gauge shall be as the recommended by the device manufacturer.

3. CONTROLS ENCLOSURES:

A. All new controllers shall be installed inside an enclosure.

B. All control enclosures shall come with a local, external on/off switch with over-current protection for power sources.

C. For enclosures directly attached to equipment that is not easily accessible (e.g. fan coil above ceiling tiles), or in other spaces that are secure and accessible only to Operations and Maintenance personnel shall be hinged with a quarter turn slotted latch.

D. For enclosures in locations accessible to personnel other than Operations and Maintenance, such as an IDF room, shall be hinged with a locking latch. A common key shall be used for all locking enclosures within the same building. Contractor shall provide at least two (2) keys per common enclosure.

E. Enclosures shall be rated for the environment they are installed in.

1. Outdoor enclosures shall be NEMA 3R.

2. Indoor enclosures shall be NEMA 1.

F. Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs or tie-wrapped. Terminals for field connections shall be UL Listed for service, individually identified per control-interlock drawings, with adequate clearance for field wiring. All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover. Control terminations for field connection shall be individually identified per control Shop Drawings.

G. Upon completion of the project, the Controls Contractor shall be responsible for providing an as-built copy of the controller points list for all points within the enclosure, as well as a system layout drawing, for mounting within the enclosure. The as-built copies shall be laminated for protection from the elements.

4. CONTROL VALVES

A. Acceptable Manufacturers:

1. Belimo
2. Or Equal

B. General:

1. 3-way valves are only to be used where specifically shown on the design drawings. Unless otherwise indicated, all control valves shall be 2-way.

C. Butterfly Valves:

1. Valve body shall be neck epoxy coated cast or ductile iron with full lug pattern, ANSI class bolt pattern to match specified flanges.
2. Valve seat shall be EPDM replaceable, non-collapsible, phenolic backed.
3. Valve disc shall be polished aluminum bronze or stainless steel, pinned or mechanically locked to shaft. Sanded castings are not acceptable.
4. Valve bearings shall be bronze or stainless steel.
5. Valve shaft shall be 416 stainless steel, supported at three locations with PTFE bushings for positive shaft alignment.
6. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.

D. Two Position Ball Valves:

1. Valves shall be specifically designed for two-position duty in control applications with guaranteed average leak-free life span over 200,000 full stroke cycles.
2. Valves shall be of industrial quality with nickel plated forged brass body and female NPT threads.
3. Valves shall be blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating (1 inch and smaller) or 400 psi rating (larger than 1 inch). The stem

packing shall consist of 2 lubricated O-rings designed for on-off service and requiring no maintenance.

4. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.
5. No characterization disks.
6. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.
7. Valve ball shall be chrome-plated brass.
8. Valve stem shall be chrome-plated brass.

E. Modulating Characterized Ball Valves

1. Valves shall be specifically designed for modulating duty in control application with a guaranteed average leak-free life span over 200,000 full stroke cycles.
2. Valves shall be of industrial quality with nickel plated forged brass body and female NPT threads.
3. Valves shall be blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating (2-way valves) or 400 psi rating (3-way valves). The stem packing shall consist of 2 lubricated O-rings designed for modulating service and requiring no maintenance.
4. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.
5. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.
6. Characterizing disk held securely by a keyed ring providing equal percentage characteristic.
7. Valve ball shall be stainless steel.
8. Valve stem shall be stainless steel.

F. Pressure Independent Control Valves

1. Pressure Independent control valves shall only be used where specifically noted in the Drawings.
2. Flow through the valve shall not vary more than +/- 5% due to system pressure fluctuations across the valve in the selected operating range.
3. Valve shall provide accurate control over its full rated flow range.

4. Valves shall have equal percentage characteristics.
5. No more than 5 psi differential pressure shall be required to operate the valve in a pressure independent mode.
6. Valve shall be maintenance-free without replaceable cartridges.

G. Minimum pressure rating for valve assemblies shall depend on application:
1. Chilled or condenser water: 125 psi at 60º F, or higher as required by application.
2. Hot water: 125 psi at 250º F, or higher as required by application.
3. Steam: 125 psi at 350º F, or higher as required by application.

H. Valve Type:
1. Modulating 2-way or 3-way valves:
a. Less than or equal to 6 inches shall be characterized ball type.
b. Greater than or equal to 8 inches shall be butterfly type.
2. Two-position isolation shall be butterfly or non-characterized ball type.

I. Valve Characteristics:
1. 2-way valves shall be equal percentage or modified equal percentage.
2. 3-way valves controlling cooling coils and condenser water heat exchangers shall be linear.
3. 3-way valves controlling heating coils shall be equal percentage or modified equal percentage.
4. Two-position valves are not applicable. For ball valves used for two-position duty, do not include characterizing disk.

J. Valve Sizing:
1. For modulating valves, Controls Contractor shall be responsible for selecting valve Cv and size unless otherwise specified on drawings. Use the highest Cv that will provide good control, while observing the following limits:
a. Minimum pressure drop shall be equal to half the pressure drop of coil or exchanger.
b. Maximum pressure drop shall be 2 psi for hot water coils and 5 psi for chilled water coils.

c. 3-way valves shall be selected for near minimum pressure drop.

d. 2-way valves shall be selected near maximum pressure drop.

e. Cv shall not be less than 1.0 (to avoid clogging) unless protected by strainer. Verify from piping schematics that a strainer is being provided.

f. Valve size shall match as close as possible the pipe size where the Cv is available in that size.

g. If good control cannot be achieved while observing these limits, the Contractor shall ask for clarification.

2. Two-position valves shall be line size unless otherwise indicated on drawings.

5. ACTUATORS

A. Acceptable Manufacturers:

1. Belimo

2. Or Equal

B. All new actuators shall include a manufacturer's 5-year warranty.

C. General:

1. All new actuators shall be UL 873 listed.

2. Actuators shall be designed for a minimum of 60,000 full cycles at full rated torque.

3. Enclosure shall meet NEMA 4X weatherproof requirements for outdoor applications.

4. Actuator shall have microprocessor-based motor controller providing electronic cut off at full open and closed with no noise generated while holding open or closed.

5. Actuators shall provide protection against actuator burnout using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling.

6. End switches to deactivate the actuator at the end of rotation or use of magnetic clutches are not acceptable.

7. Noise from actuator while it is moving shall be inaudible through a T-bar ceiling.

8. Power Requirements:
    a. All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC.
    b. Actuators operating on 120 VAC power shall not require more than 10 VA.
    c. Actuators operating on 230 VAC power shall not require more than 11 VA.
9. Actuators shall be provided with a conduit fitting and a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
10. Where fail-open or fail-closed (fail-safe) position is required, an internal mechanical, spring return mechanism shall be built into the actuator housing. Electrical capacitor type fail-safe are also acceptable. All fail-safe actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.
11. Actuators shall be capable of being mechanically and electrically paralleled to increase torque where required.
12. Include an external manual gear release to allow manual positioning of the actuator when not powered.
    a. Spring return actuators with more than 60 inch-pound torque capacity shall have a manual crank for this purpose.
    b. Large industrial actuators (e.g. for butterfly valves) shall be equipped with a hand wheel to permit operation of the valve when the actuator is unpowered.
13. Actuators shall provide clear visual indication of damper/valve position.
14. Where indicated on Drawings or I/O Schedules, the actuator shall include:
    a. Analog position feedback signal from the actuator output. The use of a separate potentiometer for position feedback is not acceptable.
    b. Limit (end) position switches. Actuator clutch switch is acceptable. Switch must prove at 0% and 100% of the field-adjusted (not

maximum) stroke of the damper. Damper end switch is not acceptable.

D. Modulating Actuators, All Types:

1. Actuators shall accept a voltage or current control signal that matches what the field controller can generate.
2. Actuators shall provide a voltage or current feedback signal that matches what the field controller can monitor if indicated on the drawing set.
3. Actuators shall have positive positioning circuit so that controlled device is at same position for a given signal regardless of operating differential pressure.
4. Actuators shall have true proportional position control. Floating point actuators are not acceptable, except where noted on the drawings and for terminal unit damper actuators, which may be floating point type if the actuators have position end switches which recalibrate position feedback when end of stroke is reached. Recalibration shall be automatic and transparent to user.
5. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.

E. Damper Actuators:

1. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The clamp shall be steel of a V-bolt design with associated V-shaped, toothed cradle attaching to the shaft for maximum strength and eliminating slippage via cold weld attachment.
   a. Single bolt or set screw type fasteners or aluminum clamps are not acceptable.
2. For multiple sections, provide one actuator for each section.
   a. Linking or jack-shafting damper sections shall not be allowed.
3. Select actuator torque and/or quantity to satisfy all of the following requirements:
   a. Opposed blade dampers shall have a minimum of 7 inch-pounds per square foot of damper.
   b. Parallel blade dampers shall have a minimum 5 inch-pounds per square foot of damper.
   c. Terminal unit dampers shall be a minimum 45 inch-pounds.

d. Actuators shall be able to provide smooth proportional control with air velocities 20% greater than maximum design velocity.

e. As required by blade and/or edge seals, per damper manufacturer.

f. The total damper area operated by an actuator shall not exceed 80% of the manufacturer's maximum area rating.

F. Valve Actuators:

1. Actuators shall be specifically designed for integral mounting to valves without external couplings.

2. Modulating actuators for valves shall have minimum rangeability of 50 to 1.

3. Actuators for 2-way and two-position valves shall have sufficient torque for:

a. Tight closing against 125% of system pump shut-off head.

b. Modulating duty against 90% of system pump shut-off head.

4. Actuators for 3-way valves shall be tight closing against twice the full open differential pressure for which they are sized.

G. Normal and Fail-Safe Position:

1. Unless otherwise specified, the requirement for fail-safe actuators and the normal positions of control devices shall be as indicated in Table 1.

2. For actuators indicated as Fail-Safe Required in the table, normal position refers to the position with zero control signal and with no power to the actuator. For actuators not indicated as Fail-Safe Required in the table, non-fail-safe style actuators are acceptable and normal position refers to the position with zero control signal.

3. Table 1

Actuator Function	**Normal Position**	**Fail-Safe Required**
Outside Air Damper	Closed	Yes
Return Air Damper	Open	Yes
Exhaust/Relief Air Damper	Closed	Yes
AHU Heating Coil Valve	Open	Yes
FCU Heating Coil Valve	Open	Yes

VAV Heating Coil Valve	Open	Yes
AHU Cooling Coil Valve	Closed	
FCU Cooling Coil Valve	Open	
Isolation Valve	Open	
VAV Box Damper	Open	

6. TEMPERATURE SENSORS

A. General

1. Unless otherwise noted, sensors may be platinum RTD, thermistor, or other device that is commonly used for temperature sensing and that meets accuracy, stability, and resolution requirements.
2. Sensor type shall be chosen based on the field controllers sensing capabilities. Sensor enclosures shall be suitable for the installation location.
3. Unless otherwise noted, sensor range shall provide a minimum resolution of 0.1° F and shall not drift more than 0.1° F over a 5-year period.
4. Temperature sensors shall not require recalibration over a 5-year period.

B. Duct Temperature Sensors

1. Acceptable Manufacturers:
   a. MAMAC
   b. Distech
   c. Or Equal
2. Single point probes shall be 304 stainless steel.
3. Averaging sensors shall have a length of at least 1 foot for every 2 square feet of duct face area up to a maximum of 25 feet. Sensor probe shall be bendable aluminum.
4. Sensor enclosures shall be gasketed in order to prevent air leakage and vibration noise.

5. Duct temperature sensors may be capable of monitoring both ambient air temperature and relative humidity if the application requires monitoring of both temperature and humidity.
    a. Relative humidity sensor shall be designed for applications with a risk of condensation. See section 2.7 for additional humidity sensor requirements.

C. Immersion Temperature Sensors
1. Acceptable Manufacturers:
    a. MAMAC
    b. Distech
    c. Or Equal
2. Sensor probe shall be hermetically sealed 304 stainless steel.
3. Immersion wells shall be machined from a single piece of brass or stainless steel.
4. Thermowells shall be capable of being removed from the system, with lagging extensions equal to or greater than the insulation thickness of where the thermowell is being installed.
5. Thermowells shall be rated to withstand the maximum system operating temperature, pressure, and fluid velocity.
6. The thermowell shank shall penetrate the pipe by the lesser of half the pipe diameter or eight (8) inches.

D. Room Temperature Sensors
1. Acceptable Manufacturers:
    a. Distech
    b. Or Equal
2. For controller makes and models that are capable of utilizing a subnetworked room sensors (e.g. Distech Allure), utilizing this subnetwork shall be the preferred method of sensing room comfort conditions in order to free up physical inputs and outputs on the controller.
    a. Subnetworked room sensors shall not be a BACnet networked device. Subnetworked room sensors shall communicate with their respective field controllers only.

b. Subnetworked room sensors shall be required to provide data to the BMS as BACnet objects.

c. Wireless communication with room sensors is not allowed unless otherwise specified by the owner.

3. Stainless steel plate temperature sensors are acceptable for areas where the risk of sensor damage is high, local adjustment is not required, and its controller has enough free inputs to utilize the sensor.

4. All room sensors shall be mounted in a vertical wall box enclosure.

5. Sensor Usage

a. Classrooms and Office Spaces:

i. Display room temperature, room temperature setpoint, and occupancy mode.

ii. Allow for push button occupancy override. Override time shall be adjustable at the GUI.

iii. CO2 and occupancy sensing shall be required for systems utilizing Demand Control Ventilation (DCV).

iv. For rooms utilizing multiple sensors, only one of the room sensors shall allow for room temperature setpoint adjustment.

b. Common Areas:

i. Display room temperature only.

ii. Pushbutton occupancy override shall not be allowed in common areas.

6. Room temperature sensors may be capable of monitoring both ambient air temperature and relative humidity if the application requires monitoring of both temperature and humidity.

a. Relative humidity sensor shall be designed for applications with a risk of condensation. See section 2.7 for additional humidity sensor requirements.

E. Outside Air Sensors

1. Acceptable Manufacturers:

a. BAPI

b. MAMAC

c. Or Equal

2. Enclosure:
    a. Sensor probes shall utilize a NEMA 4 enclosure and shall feature a UV-resistant sun shield.
3. Sensors:
    a. Outside air sensors shall be capable of monitoring both ambient air temperature and relative humidity.
        i. Relative humidity sensor shall be designed for applications with a risk of condensation. See section 2.7 for additional humidity sensor requirements.

7. HUMIDITY SENSORS
    A. General
        1. Sensor construction shall be capacitive thin-film polymer and the sensor be replaceable in the field without the need for recalibration.
        2. Sensor enclosures shall be suitable for the installation location.
        3. Unless otherwise noted, sensor range shall provide a minimum resolution of 0.1%RH and shall not drift more than 0.5%RH per year.
        4. The temperature effect on the sensor shall not exceed 0.06% per ° F at 70° F.
    B. Duct Humidity Sensors
        1. Acceptable Manufacturers
            a. Vaisala
            b. Or Equal
        2. Humidity sensors shall be capable of providing accurate data between 32° F and 120° F.
        3. Humidity sensor transmitters shall provide a voltage or current feedback signal that matches what the field controller is capable of monitoring. Sensing range shall be 0%RH to 100%RH.
        4. Sensor enclosures shall be gasketed to prevent air leakage and vibration noise.

8. DIFFERENTIAL PRESSURE TRANSMITTERS – AIR
    A. Acceptable Manufacturers:
        1. Setra
        2. Dwyer

3. Or Equal

B. All differential pressure transmitters shall include an LCD display for local reading of measured pressure.

1. Differential pressure transmitters shall provide a voltage or current feedback signal that matches what the field controller is capable of monitoring. See design drawings for expected sensing ranges.

C. Sensor signal type shall be field selectable and shall be chosen based on the field controllers sensing capabilities. Two or three wire sensors shall be acceptable.

D. Overall accuracy shall be +/- 1% of full-scale sensing capability.

E. Sensor housing shall be polymer housing that is suitable for surface mounting.

9. AIRFLOW SENSING – VAV BOX VELOCITY PRESSURE TRANSDUCERS

A. Acceptable Manufacturers:

1. Setra

2. Veris

3. Or Equal

B. Velocity pressure transducers shall provide a voltage or current feedback signal that matches what the field controller is capable of monitoring. See design drawings for expected sensing ranges.

C. Velocity pressure transducers shall be two wire differential capacitance cell type transmitter. Transmitter shall be capable of stably controlling to a setpoint of less than or equal to 0.004 in/WC of differential pressure, capable of sensing less than or equal to 0.002 in/WC of differential pressure, and shall have a resolution of less than or equal to +/-0.001 in/WC across the sensor's entire range.

1. Integrated velocity pressure sensors are an acceptable alternative if they adhere to the above conditions.

D. Velocity pressure transducers shall use a minimum of two field measured points for calibration. Field controller programming software shall be capable of field point calibration using minimum and maximum airflow with curve fitting airflow interpolation in between.

E. For non-integrated velocity pressure transducers, sensor housing shall be polymer housing that is suitable for surface mounting.

10. AIRFLOW SENSING – THERMAL DISPERSION

    A. Acceptable Manufacturers:

        1. Onicon
        2. Ebtron
        3. Or Equal

    B. Thermal dispersion airflow sensors shall provide a voltage or current feedback signal that matches what the field controller is capable of monitoring.

    C. Each stand-alone sensing point shall use an ambient temperature thermistor and an externally heated thermistor to determine the point velocity and temperature. Automatic equal area averaging of the individual point measurements shall be performed in the transmitter.

    D. Thermal dispersion airflow probe arrays shall consist of one or more multi-point measuring probes and a single microprocessor-based transmitter. The transmitter shall be supplied by the same manufacturer as the measuring station or probe array.

    E. The probe array shall be connected to the transmitter using a single cable, of up to 100' in length, included with the transmitter.

    F. Multi-point probes shall be assembled using anodized aluminum tubing, aluminum mounting plates, aerodynamically optimized molded sensing apertures to ensure accurate measurement in angular airflow conditions, and neoprene mounting gasket.

    G. Each airflow sensor shall have a minimum accuracy of +/-2% of reading for velocity measurement and 0.1 °F for temperature measurement and shall be provided with proof of a multi-point NIST traceable calibration.

    H. Individual sensors shall be field serviceable without the need for system re-calibration.

11. CROSS AIRFLOW AVERAGING SENSOR (FOR VAV AIRFLOW)

    A. Acceptable Manufacturers:

        1. Titus
        2. Krueger
        3. Or Equal

    B. Cross style airflow sensors shall be the standard requirement for measuring airflow on any VAV box. Pitot tube style airflow measurement shall not be allowed unless otherwise specified by the Owner.

C. Airflow sensor shall be cross shaped multi-point center averaging type. Single axis sensors shall not be acceptable for duct diameters six (6) inches or larger. The sensor shall output an amplified differential pressure signal that is at least one and a half (1.5) times the equivalent velocity pressure signal obtained from a conventional pitot tube.

D. A minimum of three (3) duct diameters of straight duct shall be required for the cross-airflow sensor installation location.

E. Use manufacturers balancing taps and airflow calibration charts for field airflow measurements.

12. FREEZE PROTECTION

A. Acceptable Manufacturers:

1. ACI
2. Or Equal

B. Freezestats shall be provided on all air handling units that utilize fresh air makeup and shall incorporate an external test mode switch.

C. Freezestats shall be hardwired to the air handing unit in order to stop the supply fan and shall provide hardwired status feedback to the BMS.

D. Freezestats shall also utilize a vapor filled capillary that activates freeze protection when the lowest temperature sensed by any 1-foot section of the capillary is lower than the freeze protection setpoint.

E. Access doors shall be provided for Freezestats, for removal and service.

13. CURRENT SWITCHES

A. Acceptable Manufacturers:

1. Veris
2. Senva
3. Or Equal

B. Current switches shall be clamp on or solid split core, solid state, normally open, with zero off state leakage.

C. Current switches shall be UL listed and CSA compliant.

D. Current switches shall have an adjustable range. Sensing range shall be determined by the application. Current trip shall be indicated by an LED on the current switch.

E. A combined relay/current switch is acceptable.

F. For single phase equipment, the current switch shall be in a self-contained unit with a housing and integrated override switch.

14. CONTROL RELAYS

A. Acceptable Manufacturers:

1. Functional Controls
2. IDEC
3. Or Equal

B. All relays shall be UL listed with contacts rated for their respective application.

C. Ice cube style relays shall be mounted inside the controls enclosure.

D. Relays mounted directly on equipment or external to the controls enclosure shall be mounted in a NEMA 1 housing for indoor locations and a NEMA 4 housing for outdoor locations.

E. Relays used for low voltage applications (less than or equal to 120 V) shall be required to have, as a minimum, the following:

1. AC coil pull in range of +/- 10% of nominal voltage.
2. Coil sealed VA not to exceed 4 VA.
3. Contacts shall be sealed in a dust proof housing.
4. Silver cadmium form C, with 8 or 11 pin type plug.
5. Pilot LED indicator of power to coil and coil retainer clips.

F. Relays used for start/stop control of 120 V motors with 1/3 horsepower or less shall be rated to break at a minimum of 10 A of inductive load.

G. Relays used for start/stop control shall have low voltage coils of 30 VAC or less, and shall be provided with transient and surge suppression devices at the controller.

15. CONTROL TRANSFORMERS AND POWER SUPPLIES

A. Acceptable Manufacturers:

1. Functional Devices
2. Square D
3. Or Equal

B. Transformers shall be UL listed, Class 2 current limiting type. If current limiting is unavailable, provide over current protection for both primary and secondary circuits for Class 2 service per NEC requirements.

C. Transformers shall be properly sized for their respective application. Loads shall be limited to 80% of rated capacity.

D. Transformers shall be mounted within the controls enclosure.

E. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5 mV maximum peak-to-peak. Regulation shall be 1% line and load combined, with 100 microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection, and shall be able to withstand a 150% current overload for at least 3 seconds without trip-out or failure.

F. Separate power transformers shall be used for controllers and for actuators and other end devices that use half wave rectification.

G. Unit shall operate between 32° F and 120° F. EM/RF shall meet FCC Class B and VDE 0871 for Class B, and MIL-STD 810C for shock and vibration.

H. Line voltage units shall be UL Recognized and CSA Approved.

PART 3 – EXECUTION

1. EXAMINATION

A. Thoroughly examine project plans for control device and equipment locations. Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to Engineer for resolution before starting rough-in work.

B. Examine drawings and specifications for work of others. Report inadequate headroom or space conditions or other discrepancies to Engineer and obtain written instructions for changes necessary to accommodate work with work of others. Contractor performing the installation work shall perform, at their expense, necessary changes in specified work caused by failure or neglect to report discrepancies.

2. PROTECTION

A. The Contractor performing the installation work shall protect against and be liable for damages to performed work and/or damages to material caused by work performed by the Contractor, work performed by the Contractor's employees, and/or work performed by the Contractor's Sub Contractor.

B. The Contractor performing the installation work shall be responsible for work and equipment until inspected, tested, and accepted by Owner.

C. Protect material not immediately installed.

D. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3. COORDINATION

A. Assist in coordinating space conditions to accommodate the work of each trade where work shall be installed near or shall interfere with work of other trades.

B. If installation without coordination causes interference with work of other trades, the Contractor performing the installation work shall correct conditions without extra charge.

C. Test and Balance:

1. Provide the Test and Balance Contractor a single set of necessary tools to interface to control system to perform testing and balancing.

2. The Controls Contractor and the Integration Contractor shall train the Test and Balance Contractor to use control system interface tools.

3. The Controls Contractor and the Integration Contractor shall provide a qualified technician to assist with all testing and balancing.

4. Any necessary tools that the Test and Balance Contractor needs to interface with the control system to perform testing and balancing shall be returned undamaged and in working condition at completion of testing and balancing.

D. Coordination with Other Controls:

1. Integration and operator interface software and hardware shall be provided by the Integration Contractor.

2. Integration Contractor shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.

3. Communication media and equipment shall be provided as specified in the drawing set.

4. Each supplier of a controls product shall configure, program, start up, and test that product to meet the sequences of operation regardless of where those products are described within the contract documents.

5. Coordinate and resolve incompatibility issues that arise between control products provided under this section and those provided under other specifications.

4. GENERAL WORKMANSHIP

   A. Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

   B. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

   C. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

   D. Install all devices in accordance with manufacturer recommendations.

   E. Use new products that the manufacturer is currently manufacturing and selling for use in new installations.

   F. Installations shall not be used as a product test site unless explicitly approved in writing by Owner.

   G. Spare parts shall be available for a minimum of five (5) years after completion of this contract.

   H. All devices of the same type serving the same function shall be identical and from the same manufacturer.

   I. Coordination with other trades is required wherever architectural features govern the location of Work.

   J. All controllers and associated hardware shall be capable of fully operating while maintaining specified tolerances at the ambient conditions defined below:

      1. Outside Ambient Conditions: -20° F to 120° F, 0% RH to 90% RH noncondensing.

      2. Conditioned Spaces: 32° F to 104° F, % RH to 90% RH noncondensing.

5. FIELD QUALITY CONTROL

   A. Continually monitor field installation for code compliance and workmanship quality.

   B. The Contractor responsible for installation work shall arrange for work inspection by local or state authorities having jurisdiction over the work.

6. EXISTING EQUIPMENT

   A. Interconnecting control wiring to be removed shall become the property of the Contractor responsible for installation work, unless specifically noted or shown to be reused.

B. Existing control panels not scheduled for reuse shall be removed and delivered to the Owner.

C. When removing sections of pneumatic installations, the piping shall be taken back to the point of origin and capped.

D. Unless otherwise directed, the Contractor responsible for installation work is not responsible for repair or replacement of existing energy equipment and systems, valves, dampers, or actuators. Notify Engineer in writing immediately of existing equipment that requires maintenance.

E. Deliver the following to Owner if project includes new replacements:

1. Existing room thermostats
2. Existing sensors and transmitters
3. Existing controllers and auxiliary electronic devices
4. Existing damper actuators, linkages, and appurtenances
5. Existing control valves

F. Existing mechanical system may be disabled temporarily for work to be performed during the project. A request for equipment downtime must be made to Owner at least seven (7) days prior to work that is to be performed. Execution of work may not commence without approval from Owner.

G. Maintain fan scheduling using existing or temporary time clocks or control systems throughout the control system installation.

H. Modify existing starter control circuits, if necessary, to provide hand-off-auto control of each controlled starter. Furnish new starters or starter control packages as required.

I. Patch holes and finish to match existing walls.

J. At Owner's request, items not to be delivered to Owner shall instead be properly disposed of.

7. WIRING

A. Control and interlock wiring and installation shall comply with national and local electrical codes and manufacturers recommendations.

B. NEC Class 1 wiring shall be UL listed in approved raceway as specified by NEC.

C. Low voltage wiring shall meet NEC Class 2 requirements. Sub fuse low voltage power circuits as required to meet Class 2 current limit.

D. Current limited NEC Class 2 wires in a concealed location but not in raceway but and accessible locations such as return air plenums will be UL listed for their respective application.

E. Install wiring in raceway where wire may be subject to mechanical damage and at levels below 10 feet in mechanical, electrical, or service rooms and above hard ceilings or over large pieces of equipment.

F. Install Class 1 and Class 2 wiring in separate raceways. Boxes and panels containing high voltage wiring and equipment will not be used for low voltage wiring except for the purpose of interfacing the two through relays and transformers.

G. Do not install wiring in raceway containing tubing.

H. Do not splice wires between devices and controllers. A single, continuous wire must be used.

I. Use of wire nuts for control wiring is not permitted. Control wiring will be connected using terminal blocks.

J. Class 2 wiring that is unable to be installed in raceways will be installed above ductwork and equipment at the highest point possible, run parallel or perpendicular to a surface, and supported at 5-foot intervals.

K. Use structural members to support or anchor plenum cables without raceway. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.

L. Anchored cables will be supported by J-Hooks or bridle rings. The use of cable ties is not permitted.

M. Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes will not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.

N. Size raceway and select wire size and type in accordance with manufacturer's recommendations and NEC requirements.

O. Include one pull string in each raceway greater than or equal to 1 inch.

P. Use color-coded conductors throughout.

Q. Conceal raceways except within mechanical, electrical, or service rooms. Maintain minimum clearance of 6 inches between raceway and high-temperature equipment.

R. Install insulated bushings on raceway ends and enclosure openings. Seal top ends of vertical raceways.

S. Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.

T. Flexible metal raceways and liquid-tight flexible metal raceways will not exceed 3 feet in length and will be supported at each end. Do not use flexible metal raceway less than ½ inch electrical trade size. Use liquid-tight flexible metal raceways in areas exposed to moisture including chiller and boiler rooms.

U. Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join raceway sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes with bushings.

8. COMMUNICATION WIRING

A. Communication wiring shall be low-voltage Class 2 wiring.

B. Existing serial communication wiring shall not be reused. Category 5 and 6 communication wire may be reused if the wire is properly tested and meet performance standards noted in EIA/TIA-568.

C. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

D. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer

E. Verify entire network's integrity following cable installation using appropriate tests for each cable.

F. Each run of communication wiring will be a continuous length without splices when that length is commercially available. Splices in communication wiring are not permitted.

G. BACnet MS/TP communications wiring will be installed in accordance with ASHRAE/ANSI Standard 135-2016. This includes but is not limited to:

1. The network will use shielded, twisted-pair cable with characteristic impedance between 100 and 130 ohms. Distributed capacitance between conductors will be less than 100 pF per meter (30 pF per foot.).

2. Network topology for BACnet MS/TP will be daisy chain only with a maximum device count of 32 per network segment. Other networking topologies and T taps are not permitted.

3. Additional devices may be accommodated by the use of repeaters if the network segment requires more than 32 devices.

4. The maximum length of an MS/TP segment is 1200 meters (4000 ft.) with AWG 18 cable and a maximum baud rate of 76800. A baud rate of 115200 will reduce to recommended maximum length of an MS/TP segment to 1000 meters (3280 ft.) The use of greater distances and/or different wire gauges must comply with the electrical specifications of EIA-485.
5. The maximum number of nodes per segment will be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.

9. INSTALLATION OF SENSORS

A. Install sensors according to manufacturer's recommendations.

B. Mount sensors rigidly and adequately for operating environment.

C. Install room temperature sensors on concealed junction boxes properly supported by wall framing.

D. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

E. Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.

F. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 3 m (1 ft.) of sensing element for each 1 m 2 (1 ft2) of coil area.

G. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat- conducting fluid in thermal wells.

H. Install outdoor air temperature sensors on north wall at designated location with sun shield.

I. Differential Air Static Pressure:

1. Piping to pressure transducer pressure ports will contain a capped test port adjacent to transducer.
2. Supply and return duct static pressure sensors will pipe the high-pressure tap to the duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
3. Building static pressure sensors will pipe the pressure sensor's low-pressure port to the static pressure port located on the outside of the

building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.

4. Pressure transducers, except those controlling VAV boxes, will be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration- free location accessible for service without use of ladders or special equipment.

J. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

K. Freezestats, high-pressure cut-offs, and other safety switches will be hard-wired to de-energize equipment as described in the sequence of operation. Switches will require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

L. Install discharge air temperature sensors far enough downstream of heaters to demonstrate accurate results free of stratification and hunting.

10. ACTUATORS

A. Mount actuators and adapters according to manufacturer's recommendations.

B. Actuators requiring adaptors must use adaptors approved by the manufacturer.

C. Electric and electronic damper actuators will be mounted directly on damper shaft or jackshaft unless shown as a linkage installation. Link actuators according to manufacturer's recommendations.

D. For low-leakage dampers with seals, mount actuator with a minimum 5° travel available for damper seal tightening.

E. To compress seals when spring-return actuators are used on normally closed dampers, power actuators to approximately 5° open position, manually close the damper, and then tighten linkage.

F. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

G. Provide necessary mounting hardware and linkages for actuator installation.

11. IDENTIFICATION

A. Label wiring and cabling, including that within factory-fabricated panels, with control system and wire function at each end of the wire within 2 inches of the termination point.

1. As an example, supply air temperature for AHU 3 would be noted as AHU03_SaTmp.

B. Label communication wiring to indicate origination and destination.

C. All control enclosures shall be properly labeled with nameplates on the face. Lettering on nameplate will be a minimum of 0.5 inches in height.

D. Label each control component with a permanent label. Label plug-in components such that labels remain stationary during component replacement.

E. Nameplates shall be affixed to room sensors noting equipment served.

F. Manufacturers' nameplates and UL or CSA labels will be visible and legible after equipment is installed

G. Label identifiers will match record documents.

12. CLEANING

A. Each day clean up debris resulting from work. Remove packaging material as soon as its contents have been removed. Collect waste and place in designated location.

B. On completion of work in each area, clean work debris and equipment. Keep areas free from dust, dirt, and debris.

C. On completion final of work, check equipment furnished under this section for paint damage. Repair damaged factory-finished paint to match adjacent areas. Replace deformed cabinets and enclosures with new material and repaint to match adjacent areas.

****END OF SECTION****