SECTION 25 00 00 – INTEGRATED AUTOMATION

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes general requirements for The Owner building automation system and furnishing and installing a new Direct Digital Controls and building automation system for this project.

B. Related Sections:

1. *25 01 00 Operation and Maintenance of Integrated Automation*
2. *25 05 00 Common Work Results for Integrated Automation*
3. *25 06 00 Schedules for Integrated Automation*
4. *25 08 00 Commissioning of Integrated Automation*
5. *25 11 00 Integrated Automation Network Devices*
6. *25 14 00 Integrated Automation Local Control Units*
7. *25 15 00 Integrated Automation Software*
8. *25 35 00 Integrated Automation Instrumentation and Terminal Devices for HVAC*
9. *25 36 00 Integrated Automation Instrumentation and Terminal Devices for Electrical Systems*

C. Coordination with other trades is required wherever architectural features govern the location of work.

D. Any rules and regulations of Federal, State, local authorities, and utility companies in force throughout the contract duration.

E. Agencies relevant to this specification:

1.	ANSI	American National Standards Institute
2.	ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
3.	BTL	BACnet Testing Laboratories
4.	FCC	Federal Communications Commission
5.	IEC	International Electrotechnical Commission
6.	ISO	International Organization for Standardization
7.	NEMA	National Electrical Manufacturers Association
8.	NFPA	National Fire Protection Association
9.	OSHA	Occupational Safety and Health Administration
10.	UL	Underwriters Laboratories

F. Publications relevant to this specification:

1. ANSI/ASHRAE Standard 135-2024 – A Data Communication Protocol for Building Automation and Control Networks
2. ANSI/CEA 709.1-D-2014 – Control Network Protocol Specification
3. ASHRAE Guideline 36 – High Performance Sequences of Operation for HVAC Systems
4. ASHRAE 223P - Proposed Designation and Classification of Semantic Tags for Building Data
5. FIPS 140-3 (2019) – Security Requirements for Cryptographic Modules
6. ISO 16484-5:2022 – Building Automation and Control Systems (BACS) -- Part 5: Data communication protocol

7. NEMA 250-2020 – Enclosures for Electrical Equipment (1000 Volts Maximum)
8. NFPA 70 (2023) – National Electrical Code; National Fire Protection Association; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
9. NFPA 90A (2024) – Standard for the Installation of Air-Conditioning and Ventilating Systems
10. NIST SP 800-123 (2008) – Guide to General Server Security
11. NIST SP 800-82 (2023) – Guide to Industrial Control Systems (ICS) Security
12. TIA/EIA-485 (1998) - Electrical Characteristics of Generators and Receivers for Usein Balanced Digital Multipoint Systems
13. TIA/EIA-568 (2020) - Commercial Building Telecommunications Cabling Standard
14. UL 916 (2021) – Energy Management Equipment

G. The latest editions of the publications shall apply to the BAS design and installation as applicable, as well as any approved addenda or amendments.

1.2 ACRONYMS

A.	B-AAC	BACnet Advanced Application Controller - Profile with criteria defined byBACnet International
B.	B-ASC	BACnet Application Specific Controller - Profile with criteria defined byBACnet International
C.	B-BC	BACnet Building Controller - Profile with criteria defined byBACnet 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.	BMS	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 includingAnalog/Digital conversion and program logic.
L.	FPT	Functional Performance Test - A test of the dynamic function, operation and control of the equipment and systems to verify system performance to the fullest extent.
M.	PFC	Pre-Functional Check – A check or test performed on a piece of equipment or system before, during, or after the initial startup and operation, but prior to the FPT phase.
N.	PID	Proportional, Integral, Derivative - Control algorithm used to adjust an output based upon the difference between a process variable and setpoint variable.
O.	INT	Interval - Trending increment that records data on a pre-defined time interval.
P.	IP	Internet Protocol - Set of rules governing the format of data sent over the internet or other networks.
Q.	GUI	Graphical User Interface – Term for any graphical interface allowing user to read/write data.
R.	LAN	Local Area Network – A collection of devices interconnected in one physical location.

S.	O&M	Operations and Maintenance – Term to define documentation that illustrates boththe operation and maintenance of a product.
T.	OT	Operational Technology – Term broadly encompasses building automation and energy management systems.
U.	PICS	Protocol Implementation Conformance Statement used to describe the BACnet capabilities of a device.
V.	SaaS	Subscription as a Service – Service or application subscribed for use on while on a re-occurring payment.
W.	SLA	Service Level Agreement - A commitment between a service provider and a client.
X.	UDP	User Datagram Protocol
Y.	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.

1.3 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.	Firmware	Permanent software programmed into read-only memory that also provides low level hardware control
M.	Gateway	Connects two dissimilar protocols by translating the data from one system to another system
N.	Integrate	The act of connecting disparate systems to a common platform
O.	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

P.	IP Address	A unique string of numbers separated by periods that identifies each computer using the internet protocol to communicate over a network.
Q.	Loop	Synonymous with PID
R.	The Owner	Referring to Will County
S.	Network	Multiple devices communicating with one another
T.	Non-Programmable	A device that has pre-programmed language or logic that cannot be re-written or only has pre-selectable options
U.	Notification Object	A BACnet Object that is used to send event notifications, including alarms, within a BACnet System
V.	Object	Data or packet or data on a network
W.	Operational Technology	Term broadly encompasses building automation and energy management systems
X.	Points	Software representation of virtual and physical inputs and outputs
Y.	Programmable	A device that does not have any pre-programmed language or logic
Z.	Repeater	A device used to replicate signal data in order to increase transmission distance
AA.	Router	Routes data packets across IP addresses on different LANs/WANs with the ability to allow or deny
BB.	Subnet	Also known as a subnetwork, is a logical subdivision of a network
CC.	System	Term referencing multiple pieces of equipment acting in conjunction

1.4 SYSTEM DESCRIPTION

A. The intent of this specification is to ensure that all new Operational Technology (OT) Systems, including existing systems affected by major upgrades and retrofits, utilize a standardized open protocol; that network configuration parameters are properly managed to avoid communications issues; that system objects are named consistently; and that technology systems are properly-implemented to enable The Owner to achieve scalability, interoperability, future-proofing, and data acquisition goals. All proposals, submittals, products, systems, and workmanship shall reflect these goals.

B. This standard shall require the stand-alone operation of any system and dependent sub-system, for example an air handling unit and the VAV boxes it serves, in the event of communication failure.

C. The building automation system (BAS) shall be fully automatic, with electric and electronic components as required. All controllers, sensors, and actuators shall be electronic in new work and retrofit work. BAS technology shall provide and/or support the concepts of open distributed design, interoperability, accessibility, scalability, and security. Refer to electrical and mechanical drawings and specifications to ensure full understanding of the control system scope.

D. Project scope of work shall include new, non-proprietary, open protocol native-BACnet DDC control system devices for all new building equipment and/or systems installed, and/or for all building equipment affected by a retrofit or renovation project. At The Owner's discretion, new components (sensors, actuators) and/or programming can be added to existing BACnet controller(s) if required resources are available.

E. The control system shall consist of a BACnet/IP network of new DDC controllers for the major mechanical systems and daisy-chain ethernet controllers for associated minor mechanical equipment, where only major equipment devices and routers reside on The Owner's network. High-speed BACnet MS/TP serial network(s) for minor mechanical equipment may be accepted at The Owner's discretion, when the preferred daisy-chain ethernet solution is not available. All new control system devices, including IP and MS/TP devices, shall be BACnet Testing Laboratory (BTL) Listed and in compliance with the latest revision of the BACnet protocol.

1. The system will be accessible via the Internet and/or The Owner Wide Area Network (WAN) using any web browser, and through remote access to server software. The operator shall interface via dynamic color graphics. All mechanical systems including major, minor & auxiliary equipment, building floor plan, and control devices will be depicted by point-and-click graphics. Access shall be administered by The Owner and BAS user account administration.

F. The DDC system shall be native BACnet (ANSI/ASHRAE Standard 135). Non-native BACnet devices, and BACnet gateways and/or drivers are not permitted, and exceptions shall be subject to approval at the sole discretion of The Owner. All BACnet devices and objects shall be discoverable; hidden devices or objects are not permitted.

G. The addition of new operational technology devices and components shall be coordinated with The Owner and must be implemented with a comprehensive understanding of the existing system's architecture and limitations, to ensure seamless integration and maintain system integrity.

1.5 PRICING

A. Contractor is responsible for adhering to the schedule provided by the General Contractor.

B. Contractor is responsible for verifying current licensing, upgrading all licenses as needed to include the devices for the project, and maintaining the license through the warranty period.

C. Contractor to provide separate prices for base bid and add alternate options.

D. Base Bid:

1. All work shown on drawing set and specified throughout this document.
2. Base bid requirements on drawing set are noted as "BASE".

E. Alternates:

1. Alternate bid requirements on drawing set are noted as "ADD ALT." and includes monitoring of all actuator positions. Controller model shall be upsized as needed to accommodate actuator position monitoring.

F. Unit prices shall include all equipment, labor, materials, design engineering, startup, and testing cost to provide a fully operational control system.

1.6 SYSTEM PERFORMANCE

A. The building automation system shall comply with the following performance requirements:

1. Control/Monitoring Layer –

a. Control Layer:

i. Control logic shall execute at least once every second.

ii. Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at adjustable rate. (Begin with 1 second and adjust as required during start up and commissioning.)

iii. Reliably record all required object values at the specified interval(s), store the data locally for a minimum of 48 hours, and efficiently transmit the data to the enterprise & data historian layers periodically as specified.

iv. BACnet/IP Data Speed: All IP-based devices shall communicate at a minimum of 100 Mbps.

v. All MS/TP networks shall be configured to communicate at the highest speed at which all devices on the network are capable of, according to manufacturer recommendations.

vi. Reporting Accuracy and Stability of Control for Controller: Report values and maintain measured variables within tolerances as follows:

1. Water Temperature: ±0.4^0
2. Water Flow: ±4% of full scale

3. Water Pressure: ±3% of design
4. Space Temperature: ±0.4^{0}F
5. Ducted Air Temperature: ±0.4^{0}F
6. Outside Air Temperature: ±0.4^{0}F
7. Dew Point Temperature: ±2^{0}F
8. Temperature Differential: ±0.25^{0}F
9. Relative Humidity: ±4% RH
10. Airflow (Pressurized Spaces): ±10% of design
11. Airflow (Measuring Stations): ±10% of design
12. Airflow (Terminal): ±10% of full scale
13. Air Pressure (Space): ±0.01" wg.
14. Air Pressure (Ducts): ±0.1" wg.
15. Electrical: ±1% of reading

b. Monitoring Layer

i. Modbus TCP/IP Data Speed: All IP-based devices shall communicate at a minimum of 100 Mbps.

ii. Reporting Accuracy and Stability of Control for Monitoring Devices: Report values and maintain measured variables within tolerances as follows:

1. Fluid Temperature: ±0.4^0
2. Fluid Flow: ±4% of full scale
3. Fluid Pressure: ±3% of design
4. Outside Air Temperature: ±0.4^{0}F
5. Electrical: ±1% of reading
6. Energy: ±0.2% of reading

2. Integration Layer (if applicable)

a. Integrated devices using serial communications shall be limited to thirty-two (32) devices per serial network. If this network is a sub-network to another serial network, the devices count against the higher network's device maximum of 32 devices. No more than two serial networks (of any protocol) shall be hosted/routed by a device, and a maximum of sixty-four (64) devices (all devices and protocols combined) may obtain IP connectivity through any single IP connection.

b. All devices communicating through the Integration layer shall be subject to the same performance standards as non-integrated devices and shall support response times appropriate to achieve the specifications in the Enterprise layer.

c. Due to compatibility and performance issues, integration devices such as gateways are highly discouraged, and will only be approved by The Owner in extreme circumstances.

3. Enterprise Layer

a. Operational uptime for the enterprise software application must be 99.9%, and system or accessibility downtime caused by data storage failure must be 0 minutes.

b. Graphics and visualizations: Each graphical representation shall load and populate all data points with current data within 5 seconds of being launched.

c. Building Automation System:

i. Graphics: Each graphic shall be capable of hosting a minimum of 30 dynamic points and shall update all points on the graphics with current data every 5 seconds minimum.

ii. Object Command: Support a reaction time of less than two seconds between operator command of an output object and device reaction.

iii. Update Time: Transmit change of present values to graphic display within 5 seconds of the change occurring at the device level.

iv. Alarm Response Time: Annunciate alarm at all active alarm management consoles within 10 seconds. Issue and receive alarm notifications within 15 seconds of notification trigger criteria being met.

4. Historian Layer

a. The Trend Data Historian shall be a BACnet and Modbus Client capable of retrieving BACnet Trend Log data from field controllers with automatic scheduled synchronizations.

b. The Trend Data Historian shall be capable of receiving CSV, OPC or SQL data from multiple sources.

c. The historian software shall be configured to store a minimum of two (2) years of data for each trended object.

d. System shall display visualization (graph, table, CSV export) of up to 1 million data samples within 30 seconds. Data visualizations shall be accessible and configurable via webinterface.

e. Database shall be distributable across disks, servers, and data centers, and logically optimized for network efficiency. Database shall be open-protocol or open API to accommodate future needs and applications.

f. Database shall have configurable redundancy features and shall be repairable and upgradable without causing system downtime.

g. Disaster recovery (DR) options shall be outlined for system and data. DR setup shall be supported by Controls Contractor and The Owner's ICT team as required to facilitate DR implementation and testing.

h. Operational uptime for the system must be 99.9%, and system or accessibility downtime caused by data storage failure must be 0 minutes.

1.7 EXISTING SYSTEM MODIFICATIONS AND ADDITIONS

A. Controls Contractor to include all required services, software, and hardware to integrate any new Ethernet device into The Owner's existing operational technology systems.

B. Procedure

1. All controls work noted on the drawing set and within this document shall be provided by the Controls 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 and/or visualizations shall be created on the front-end system specified by The Owner. 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 the OT system, these devices shall be made available toThe Owner's operations and maintenance personnel for monitoring and control.

1.8 ADMINISTRATIVE REQUIREMENTS

A. The Owner requires Controls Contractors to adhere to an appropriate level of communication as determined by the specific project. This includes but is not limited to:

1. Promptly returning phone calls and emails within 24 hours on business days and 48 hours on weekend days.

2. Timely response to or delivery of submittals, RFIs, punch lists, and observations logs.
3. Attend and participate in any required coordination / start-up meetings.
4. Acknowledgement of aforementioned communications shall be made by the Controls Contractor within one business day of initial notification and shall include a resolution or planned date of resolution.

B. Pre-installation Meeting: Conduct a pre-installation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

1.9 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 Controls Contractor has responded to all comments to the satisfaction of The Owner, the Design Professional and/or The Owner's Representative.

B. Provide all literature, proposals, submittals, and as-built documentation electronically. Also provide printed records where specified.

C. BACnet Communication: Clear communication regarding BACnet is essential. Therefore, all documentation and literature shall refer to BACnet topics and concepts using standardized terminology. Refer to ANSI/ASHRAE Standard 135 – 2024 BACnet for proper terminology. Any documentation that does not meet the terminology requirements or fails to include the required information will be rejected.

D. Contractor is 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 Contractor from meeting the project schedule unless they receive approval of schedule change by The Owner.

E. The submittal schedule shall be as follows unless otherwise approved 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, when applicable, 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 conducting the first training class.

F. 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 IFC set stamped with all accepted drawings and products in a single electronic file.
   b. Electronic copies for coordination with other trades.

G. 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 with links to pages and bookmarks)
      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. For BACnet Controllers, information should include BACnet PICS, BIBB, and BTL-listing certificates for all networked devices, and IT security hardening guide. Include a description of the product's BACnet implementation, including diagrams and technical information regarding the specific requirements and limitations of the implementation. PICS shall include at a minimum:
         1. BACnet Standard Application Services Supported: This table confirms the BACnet services supported by the device.
         2. Standard Object Types Supported: This table lists the device's supported object types. It also indicates if the object is dynamically creatable, dynamically delete-able, optional supported properties, and writable properties.
         3. Data Link Layer Options: Describes the network types supported for communications, e.g., BACnet/IP, or MS/TP.
         4. Special Functionality: Describes any special exceptions the device may have to the BACnet protocol to perform any special or proprietary functions.
         5. Property Range Restrictions: Indicates, among other things, the number of characters allowed for the various text properties, such as Object Name and Description.
         6. The project technical specifications should act as the submittal review criteria. The information provided by the PICS should be compared to the technical specifications to ensure the device will function in the system as intended by the design.
   d. Manufacturer datasheets that contain a series of components must clearly indicate the specific

component that is applicable to this project. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

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 ascut 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 andthe 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, if applicable

iv. Previous device in daisy chain installation

v. Hosted Network Information

c. For mechanical systems, 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. Building system schematic layout drawing will depict the system layout, system components, sensor locations, device tags, object names & point addresses. Part numbers & sensor ranges may be displayed on this drawing if space permits.

e. All physical points on the schematic flow diagram shall be indicated with point naming, descriptors, and point addresses identified as listedin 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, meters, 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 thatare factory-installed and portions to be field-installed.

g. The bill of materials, with device tagging that correlates to the system schematic, 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 shallbe used as indicated in these specifications where applicable.

   ii. Description.

   iii. Proposed manufacturers make and model.

   iv. Range.

   v. Quantity.

h. For mechanical systems, valve schedule sheet providing individual valve and actuator information, including:

   i. Valve Tag

   ii. Pipe and valve size

   iii. Cv

   iv. Design flow

   v. Target pressure drop

   vi. Proposed manufacturers make and model

   vii. Actual valve pressure drop at design flow

   viii. Close off rating

   ix. Normal position of fail-safe actuators

i. Floorplans noting proposed field device installation locations and thermostat locations, as applicable.

j. Control System Software: Include technical data for the front-end operating system software, operator interface, graphical user interface, and other third-party applications provided by the controls supplier.

k. Application Specific Software: Include technical data for all application specific software used to configure, start-up, check-out and maintain the application specific controllers provided by the controls supplier.

l. Device Schedule: A device schedule including data for all OT network devices shall be submitted. The contractor shall submit the schedule containing all information as detailed in section 25 06 00 in order to obtain the IP address for each device from The Owner’s ICT team.

m. Object Naming: An Object Naming Submittal using shall be submitted containing the object names for all system objects. The contractor shall submit the schedule containing all information as detailed in section 25 06 00 in order to obtain approval to start database work.

n. Computerized Maintenance Management System (CMMS): A CMMS Submittal shall be submitted for all building automation, lighting control, and meter equipment. The contractor shall submit the schedule containing all information as detailed in section 25 06 00 in order to obtain approval for installation work.

o. Where specific information is not available during the submittal phase of the project, that information can be omitted and submitted during the as-built phase.

p. Manufacturer's Instructions: Indicate manufacturer's installation, operation, and maintenance (IOM) instructions for all manufactured components.

3. Submittal Package for Programming and Graphics (when applicable)
    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 Contractor to clarify or improve the sequences. 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, system enable conditions, start-up procedures, operating modes, staging & transitions, disable conditions & shut-down procedures.
        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 Front-End User Interface Requirements.
        i. At minimum, the graphics shall include a home page, navigational pages, floor plan layouts, with final and accurate room numbers, and individual graphics for all monitored systems (major, minor & auxiliary)
        ii. The graphics shall depict all hardwired points, all setpoint & all pertinent data (connected and calculated)
        iii. The object name, point address, and operator notations shall be shown for all points on the graphic.
        iv. Provide PDF images for review.
    e. Additional hardware and software requirements for any proposed software installations as stated in section *25 15 00 Integrated Automation Software*.

H. Training Material and Checkout Forms
1. The following will be provided as part of the Checkout Forms for each device:
    a. A checkout form will be provided for each device. The checkout form will include, but is not limited to, the following:
        i. Point-to-point testing (see also 25 08 00 Commissioning of Integrated Automation).
        ii. Device Communication Status
        iii. Communication Errors and Repair Requirements
        iv. GUI Function Tests at All Operator Stations, including ensuring The Owner's data needs are met
2. See section 1.12 for Training Material requirements.

I. Submittal checklist is available in Appendix A.

1.10 COMPLETION REQUIREMENTS

A. 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 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.

B. Record Documents:

1. Operations and Maintenance manuals in electronic formats and in paper if requested. 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. All information included in the design submittal shall be updated to reflect as-built conditions and shall include any information omitted during submittal phase due to unavailability.
        i. Record final installation locations of control devices and components including controllers, power supplies, network cabling routes, and remote sensors such as outside air sensors & differential pressure sensors. Ensure that clear marking of all system sensors, thermostats, and meters on the as-built floor plan and HVAC or Electrical drawings, respectively, with their control system designations are included.
        ii. Provide all as-built documentation electronically in a searchable PDF with PDF accessible tabs dividing each section. Also provide printed records where specified.
    c. Sequence of Operations
        i. Provide all As-Built Sequence of Operations, updated to reflect any edits to programming made to meet design intent, in separate editable files (Word Documents).
    d. System O&M Manual: The O&M Manual shall be included as an attachment to the final record document set, and shall compile & organize all information required to sustainably operate & maintain the control system as follows:
        i. Index and clear table of contents for the O&M Manual
        ii. Manufacturer documentation detailing the recommended inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances for all equipment provided. This includes all network equipment, controllers, sensors, valves, dampers, etc.
        iii. A separate points list export from each IP controller in the device schedule that includes all objects, physical and virtual, in that controller and any controllers it supervises such as VAV box controllers. Each report shall contain the object name and description at a minimum. Including the panel name and point address is preferred when possible. All object names shall conform to the original Object Naming submittal for the project.
        iv. A setpoints list showing all control system setpoints after testing & final system acceptance. This list shall show the setpoint name, finalized default value, engineering units, controller location, applicable system, and any other pertinent information.
        v. When applicable, a schedules list showing all equipment schedules and calendars including the schedule name, schedule type, controller location, indication of controlled equipment and whether optimal start/stop features have been implemented.
        vi. A programs list of all programming logic including the program name, systems served, controller location & a reference to the associated sequence of operations.
        vii. Full record of all control logic programming showing all comments, program logic & associated references after testing and acceptance of the system.
        viii. Specific step-by-step instructions on how to perform and apply all functions, features, modes,

etc. mentioned in section 25 08 00 Commissioning of Integrated Automation. Include the detailed technical manual for programming, tuning, and customizing control loops and algorithms.

ix. Copies of all documentation of point-to-point and functional checkout tests and calibrations performed by the Contractor (not commissioning tests).

x. Warranty information & requirements for all system components including manufacturer warranties for hardware as well as workmanship & software-based warranties for database and programming logic operations.

e. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in The Owner's name and registered with manufacturer. Provide The Owner with contact information and procedure for warranty requests.

f. 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.

3. As-built record documentation checklist is available in Appendix A.

1.11 QUALITY ASSURANCE

A. Perform work in accordance with NFPA 70.

B. Perform work in accordance with NFPA 90A.

C. 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.

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

E. 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 ofthe project

F. 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.

G. 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, thefollowing:

1. Referenced Drawing

2. Referenced Specification Number/Section

3. Contact Person

4. Request and Proposed Solution

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

I. Controls Contractor Personnel Requirements:

1. The Controls Contractor shall have a minimum of five (5) years of demonstrated technical expertise with the proposed integrated 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 devices for a minimum of 1 year.

2. The Controls Contractor Project Manager shall have a minimum of three (3) years of experience with 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 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.
6. Any third-tier subcontractor utilized by The Controls Contractor shall meet the above requirements and receive approval from The Owner to work on the project.

J. 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.

1.12 WARRANTY

A. See section 25 01 00 for warranty requirements.

1.13 OWNER TRAINING

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

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

C. For each Controls Contractor, a minimum of 16 hours of training will be provided to The Owner, organized into 2 separate sections at 8 hours a piece, unless otherwise stated by The Owner. For larger projects involving more complex building systems, such as research labs, a minimum of 24 hours of training will be required to The Owner.

D. 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.

E. Proposed training instructor qualifications will be provided to The Owner and subject to approval by The Owner.

F. Training will include classroom instruction and hands on field instruction. Training shall be recorded and provided to The Owner at The Owner's request.

G. Operator training shall be provided by each Controls Contractor after final acceptance of the system. Each Controls Contractor shall provide operator training separately to the Building Manager, The Owner personnel identified, and to the O&M contractor building operators. Provide operator training covering topics including at minimum:

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

a. Logging on and off
b. Administrative accounts or passwords

5. User Account Administration
   a. Explain how user accounts are administered
   b. Adding, editing & removing users
   c. Linking to windows active directory (if applicable)
6. System navigation
   a. Menu penetration and broad overview of the various functions and features
   b. System Tree Navigation
   c. Graphics/ Visualization Navigation
7. Trending
   a. Accessing, viewing & exporting trend data
   b. Adding, editing & removing trends
   c. Trend collection and archival functions
8. Alarming
   a. Accessing, viewing & exporting alarm data
   b. Adding, editing & removing alarms
   c. Alarm routing & management including alarm acknowledgement and dismissal
   d. Remote notification capabilities (Email, SMS, Phone, Etc.)
9. Scheduling
   a. Accessing, viewing & exporting schedules
   b. Adding, editing & removing schedules
   c. Creating holiday calendars & exceptions
   d. Schedule priorities
10. Reporting
    a. Configuring, running & exporting data from reports
    b. How to create a report to show an audit log
    c. How to create a report to show all manually overridden points
    d. How to create a report to show the status of a given selection of networked devices
11. Commanding & releasing points
    a. How to command/override an object and how to manipulate the priority at which it is commanded
    b. How to release an object back to automatic control
    c. How to determine what priority an object is currently controlled at
12. Changing default values
    a. How to change an object's relinquish default value
13. Programming
    a. Accessing and editing control logic programming in the field controllers including creating new programs, opening existing programs, editing programs, saving programs, enabling/disabling programs, and loading programming to panel's database

14. Panel backup & restore functions
    a. Explain how field panels database backups are obtained, where they are stored, and how they are restored to a controller in the event of a corrupted database, failed controller, or restoration of database in a new controller.
    b. Explain how controller database templates are creates and deployed for typical equipment, including tips and best practices.
15. System backup & restore functions
    a. Provide complete step-by-step instructions for creating a backup of the entire system (including all supporting files & software applications installation files)
    b. Explain and demonstrate an entire systems database backup.
    c. Explain how the entire system database is backed up and restored in the event of a corrupted database or failed server.
16. Licensing
    a. Explain what licensing is required to run the system and how to see the status of that licensing.
    b. Explain in detail how licenses are selected & installed and explain the license upgrade process.
17. Local Controller Access and Functionality
18. Navigating the help file(s), owner's manual(s), user guide(s)
19. Troubleshooting procedures
20. Warranty service request procedures
21. 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 withthe same level of detail as described above.

H. All training shall be recorded and provided to The Owner for internal use. If available, access to online modules and resources shall be provided for ongoing support.

I. Demonstrate these activities and provide training materials that include step-by-step instructions to perform these functions. Training materials shall be provided electronically and shall be referenced during training.

J. Coordinate training scheduling and attendees with The Owner. Document training invitations and attendance and submit training documentation to The Owner.

K. Minimum requirements for field instruction:
    1. Walkthrough of the project to locate integrated components

1.14 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. Programmable Device Databases
    4. Custom Logic

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 EXAMINATION

A. Perform site inspection prior to work performed to verify equipment can be installed as notedin 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.

3.2 PROJECT MANAGEMENT

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

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

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

D. The Controls Contractor will provide an updated project schedule, with all applicable milestones, atleast 1 day prior to the project meeting.

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

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

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

3.3 BUILDING MANAGEMENT SYSTEM SWITCH OVER

A. When applicable, 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 siteduring switch over.

B. Any required downtime to subsystems scheduled for integration into the buildingmanagement system will be limited to 24 hours and scheduled with The Owner.

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 integrationand switch over has been completed.

1. The Controls Contractor will allow time to perform function tests of allintegrated 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.

3.4 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 Controls 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 and hardware shall be neatly compiled and handed over to The Owneronce demolition is complete, unless otherwise stated by The Owner. Any demoed devices not turned over to the owner must be disposed of in a responsible and environmentally ethical manner. Any hardware not turned over to owner may not be resold without owner permission

4. Any demolished devices shall be removed from the building-level and server database to maintain system functionality.

END OF SECTION

SECTION 25 01 00 – OPERATION AND MAINTENANCE OF INTEGRATED AUTOMATION

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the requirements for operation and maintenance of integrated automation systems.

B. Related Sections:

1. *25 00 00 Integrated Automation*
2. *25 05 00 Common Work Results for Integrated Automation*
3. *25 06 00 Schedules for Integrated Automation*
4. *25 08 00 Commissioning of Integrated Automation*
5. *25 11 00 Integrated Automation Network Devices*
6. *25 14 00 Integrated Automation Local Control Units*
7. *25 15 00 Integrated Automation Software*
8. *25 35 00 Integrated Automated Instrumentation and Terminal Devices for HVAC*
9. *25 36 00 Integrated Automation Instrumentation and Terminal Devices for Electrical Systems*

1.2 REFERENCES

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

1.3 ACRONYMS

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

1.4 DEFINITIONS

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

1.5 SYSTEM DESCRIPTION

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

1.6 SUBMITTALS

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

1.7 SERVICE REQUIREMENTS

A. Maintenance Service

1. Provide service and maintenance of Integrated Automation system for one year from date of final acceptance. All service and maintenance activities shall be coordinated with The Owner.
2. Provide two complete inspections per year, one in each season, to inspect, calibrate, update, and adjust controls as required. Provide service as needed to repair hardware, software, and/or workmanship. All inspection and service activities shall be coordinated with The Owner, accompanied and supervised by an The Owner representative, and shall include a written report detailing the work performed.
3. Provide software and/or firmware updates as needed to address product software/firmware issues (bugs, security vulnerabilities) for a one-year period. The Owner shall be notified as software and/or firmware updates/upgrades are made available. All software/firmware updates shall be coordinated with The Owner. Release-note literature for software/firmware updates shall be submitted to The Owner prior to updating and device or system and shall proceed upon The Owner approval. No software or firmware updates or upgrades to IP-based devices shall be performed without prior The Owner's ICT team's security approval.
4. Two-year warranty shall be included, and shall cover all products, services, and workmanship. Warranty shall cover normal and emergency service for issues resulting from problems with products, services, and/or

workmanship. Systemic or chronic issues identified during the warranty period shall be rectified to eliminate the systemic or chronic nature of the issues; where this is not possible the Contractor shall remain liable for repeated correction of the issue indefinitely.

5. Normal warranty service requests shall be acknowledged within one (1) hour during normal office hours, and on-site service provided within 48 hours for non-critical issues (issues that do not have an immediate or significant impact on occupants, energy cost, or operations). Emergency warranty service requests shall be acknowledged within one (1) hour, and on-site service provided within four (4) hours for critical issues (issues that do have an immediate or significant impact on occupants, energy cost, or operations).
6. Products that become unavailable or unsupported during the warranty period shall be replaced with currently available and supported products by The Controls Contractor at The Controls Contractor's expense.

1.8 SYSTEM PROJECT CLOSEOUT REQUIREMENTS

A. Contractor shall be responsible for operation and maintenance of the system until Final Acceptance is obtained from The Owner. Warranty period does not begin for any aspect of the OT system until Final Acceptance has been obtained.

B. Final Acceptance Requirements:

1. Complete and accurate As-Built data has been submitted and accepted.
2. All tools (including hardware and software applications) and manuals have been submitted and accepted.
3. System Test and Balance (TAB) and any 3rd-party Commissioning has been completed.
4. All punch list items have been resolved to the satisfaction of The Owner.
5. The Owner training has been completed.
6. Complete system backups have been created and stored for disaster recovery (DR).
7. All warranty information has been completed and submitted.

C. After Final Acceptance has been obtained from The Owner, a letter shall be submitted to indicate the beginning of the warranty period. The warranty period shall not be backdated to any date prior to the date of Final Acceptance.

1.9 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 system functions satisfactorily during the testing and commissioning phase.

C. Vendor specific warranty information will be provided as part of The Controls 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 24 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 will respond during normal business hours within 48 hours of a warranty service request for normal issues, and no more than 4 hours for emergency issues.

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.

Software fixes and firmware updates shall be completed outside the general business hours of 8AM-6PM CST.

J. At the end of the warranty period, The Controls Contractor will be responsible for verifying any newly installed software and firmware are updated to the latest revision.

K. Expiration of the warranty period does not relieve the 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 Controls 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. If devices are reused The Controls Contractor shall provide a report that clearly indicates which items are existing and were reused and which items are new. All devices that are reused shall be upgraded to the latest firmware version supported by that device prior to commissioning.

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

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 NOT USED

END OF SECTION

SECTION 25 05 00 – COMMON WORK RESULTS FOR INTEGRATED AUTOMATION

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the requirements for common work results for integrated automation systems.

B. Related Sections:

1. *25 00 00 Integrated Automation*
2. *25 01 00 Operation and Maintenance of Integrated Automation*
3. *25 06 00 Schedules for Integrated Automation*
4. *25 08 00 Commissioning of Integrated Automation*
5. *25 11 00 Integrated Automation Network Devices*
6. *25 14 00 Integrated Automation Local Control Units*
7. *25 15 00 Integrated Automation Software*
8. *25 35 00 Integrated Automated Instrumentation and Terminal Devices for HVAC*
9. *25 36 00 Integrated Automation Instrumentation and Terminal Devices for Electrical Systems*

1.2 REFERENCES

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

1.3 ACRONYMS

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

1.4 DEFINITIONS

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

1.5 SYSTEM DESCRIPTION

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

1.6 SUBMITTALS

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

1.7 GENERAL REQUIREMENTS

A. For the building automation system, provide BACnet direct digital controllers, low voltage power supplies, sensors, switches, relays, control valves, dampers and operators, actuators, indicating devices, interface equipment and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.

B. For new buildings the BAS system with be installed on a dedicated BAS network that is connected to the Will County network. Owner to provide network architecture diagram upon request. Controls' contractor will provide all cabling, routers and network switches.

C. Provide all software (including any licensing required), hardware (special cables, portable operator terminals, etc.), and administrator access privileges required to allow full configuration, programming, and administration of all system components and devices provided.

D. Include installation and calibration, supervision, adjustments, and fine tuning necessary for a complete and fully operational system.

E. Controls for variable air volume terminals, radiation, reheat coils, unit heaters, fan coils, and other minor equipment when directly connected to the control units.

1.8 WORK RESULTS FOR BACNET

A. BACnet Definitions

1. BACnet: ***ANSI/ASHRAE Standard 135-2024***
2. BACnet Device Types:
   a. BACnet Router (B-RTR): device that connects two BACnet networks, permitting information exchange between them.
   b. BACnet Building Controller (B-BC): A general-purpose, field-programmable device capable of carrying out a variety of building automation and control tasks. Typically controls major equipment and/or provides supervisory control.
   c. BACnet Advanced Application Controller (B-AAC): A fully programmable controller.
   d. BACnet Application Specific Controller (B-ASC): A controller intended for use in a specific application with limited programmability. Typically controls minor equipment such as VAV terminal units.
   e. BACnet Smart Sensor (B-SS): A simple sensing device intended for a specific application.
   f. BACnet Smart Actuator (B-SA): A simple control device intended for a specific application.
   g. BACnet Advanced WorkStation (B-AWS): Used to monitor the performance of a system and to modify parameters that affect the operation of a system.
   h. BACnet Operator WorkStation (B-OWS): Used for monitoring and basic control of a system. ix. BACnet Operator Display (B-OD): A basic operator interface with limited capabilities.
   i. BACnet Gateway (B-GW): A device that connects a BACnet network to a dissimilar network or device, permitting information exchange between them.
   j. BACnet Broadcast Management Device (BBMD): A device that propagates BACnet broadcast services from one network to another network.
3. BACnet Client: A BACnet device requesting information from and/or sending supervisory commands to a BACnet Server or BACnet Servers.
4. BACnet Server: A BACnet device that responds to requests and/or supervisory commands from a BACnet Client device.
5. BACnet Interoperability Building Blocks (BIBBs): Standard technical functionality blocks used to describe the capability of a device to interact with BACnet services. Each BIBB has a client version (A) and a server version (B). A single BACnet device can support both A and B versions of a BIBB.
6. BACnet Protocol Implementation Conformance Statement (PICS): Document that describes in technical detail the BACnet implementation applied to a device, including which BACnet Interoperability Building Blocks (BIBBs) apply to the device.
7. Native-BACnet: A controller that uses BACnet as the primary communication protocol and does not require the use of a gateway or translator to be BACnet-compliant.
8. BACnet Testing Laboratory (BTL): A laboratory that tests and certifies BACnet devices for conformance to the BACnet standard.
9. Bounded/Unbounded: An unbounded broadcast refers to a BACnet broadcast that is sent to all BACnet device IDs on the entire internetwork. A bounded broadcast is sent only to a subset of device IDs. Unbounded confirmed broadcast messages can result in BACnet storms. Bounded confirmed broadcast services mitigate the risk of storms by reducing the scope of the communications to only those devices that are specified, which limits the number of potential responses.

B. BACnet Services

1. Normal Services (directed to a specific BACnet device)
2. Broadcast Services (directed to multiple BACnet devices)

a. Who is?

i. The Who-is? service is to be used in limited ways to avoid BACnet storms:

1. Unbound discovery is prohibited; use bounded Who-is? messages to limit responses.
2. Who-is? shall not be required for daily operation of the BAS or integration system; Who-is? is a discovery tool only. System devices are required to cache device discovery information and use directed communications to achieve interoperation.
3. Any system or device incapable of controlling and/or disabling Who-is? broadcast services it is capable of initiating will not be accepted.

b. Who-has?

i. The Who-has? service shall not be used in normal day-to-day operation; system devices are required to cache object locations and use directed communications to achieve interoperation.

1. A device may use Who-has? to initially gain access to a network object, but thereafter this information shall be cached.
2. System devices shall not reissue Who-has? on a return from power failure or other system disruption. Device or system backups shall retain cached object locations. Who-has? is permitted only in cases of programming changes.
3. The system must be capable of disabling the Who-has? service.
4. The system must be capable of configuring the Who-has? service to limit and bound its use.
5. Any system or device incapable of controlling and/or disabling Who-has? broadcast services it is capable of initiating will not be accepted.

c. Time synchronization

i. The Time-sync broadcast service must be configurable to include only intended recipients; only bounded time broadcasting is permitted. Directed Time-sync communications is preferred.

d. Broadcasting on IP Networks

i. General Broadcasting Guidelines:

1. Broadcast services of any kind must not be used except where absolutely necessary.
2. Where broadcast services are used, testing must be performed to ensure that the broadcasts and/or the responses do not cause system instability or loss of performance.
3. Unbounded broadcast services are strictly prohibited. Any system that requires the use of unbounded broadcast services or is unable to be configured to use bounded broadcast services, shall not be accepted.

e. Multicasting

i. Systems that require multicasting will not be accepted.

f. BBMDs

i. The use of BBMDs, where that functionality might be desirable, shall be regulated at the discretion of The Owner. Any device capable of BBMD functionality must have that functionality disabled until The Owner expressly approves the functionality for each specific device.

g. Foreign Devices

i. BBMD-capable devices must also support foreign device registration.

h. Read_Property Service

i. Execution of the Data-Sharing Read-Property service shall transmit all characters of the property; truncation is not permitted.

C. BACnet Devices

1. All BACnet devices shall be BTL-listed. The specific model and firmware version shall be BTL-listed.
2. BACnet networks:
   a. The following devices shall be BACnet/IP:
      i. B-RTR
      ii. B-BC
      iii. B-AAC
      iv. B-AWS
      v. B-OWS
      vi. B-GW (where exceptions are granted)
   b. BACnet MS/TP may be used for the following devices:
      i. B-ASC
      ii. B-SS
      iii. B-SA
      iv. B-OD
3. Each BACnet/IP device will be assigned an IP address and subnet mask by The Owner. The use of any non-Owner provided ethernet switches or hubs are not permitted. BACnet/IP devices shall support dual IP ports and shall be wired and configured in a daisy-chain network architecture between devices, with a single IP connection per segment to The Owner's IT infrastructure.
4. BACnet devices and networks must be configured optimally for high-performance and low response latency. Serial networks (MS/TP) must be sized to perform without latency issues, regardless of the traffic imposed on them to support control, monitoring, and trending functions.
   a. BACnet/IP devices shall communicate at 100 Mbps minimum.
   b. BACnet MS/TP devices shall communicate at 38.4 kbps at minimum.
      i. Exceptions shall be subject to prior The Owner approval, and if approved, shall be segregated on a separate "slow" MS/TP network or networks.
      ii. End of line terminators shall be utilized at the physical extremities of all serial network segments. End of line terminator shall be the same type and manufacturer at both network extremities.
   c. BACnet MS/TP networks communicating at 38.4 kbps or greater shall have no more than 32 devices communicating through the BACnet device supporting the MS/TP network. (This includes any non-BACnet devices connected through a gateway, where exceptions have been granted by The Owner.)
   d. BACnet networks shall be configured to communicate at the highest speed at which all devices on the network are capable of, according to product technical data. Manufacturers' "best practices" do not absolve the vendor from providing networks that operate at maximum speed.

D. BACnet Parameters

1. BACnet parameters must be configurable and shall be set per The Owner instructions provided via the Device Schedule.
2. BACnet parameters include:
   a. Device Object Name
   b. Device ID
   c. Network number

d. UDP port

i. UDP ports are assigned based on BAS vendor/product. Other building systems, such as lighting control systems, will typically use the same UDP port as the host BAS at the facility. These will be assigned to produce an overall architecture that ensures proper interoperability.

ii. BBMD feature settings (disabled unless specifically permitted by The Owner)

e. BACnet parameters shall be obtained from The Owner.

f. BACnet MS/TP devices shall communicate at manufacturer recommended speed.

i. BACnet parameters are managed by The Owner.

g. Automatically generated BACnet parameters are not permitted. Products that include automatically generated BACnet parameters shall be capable of being manually configured; devices that only support automatically generated BACnet parameters that cannot be manually custom-configured are not permitted.

E. BACnet Implementation

1. During the execution phase of the project, coordination with The Owner required to avoid or plan for potential system disruption. A risk and impact assessment must be performed prior to any activity that might disrupt existing system functionality. System outages must be planned three (3) weeks prior to work being performed.

2. Activities that may impact existing system performance include (but are not limited to):

a. Adding a new controller to the network

b. Removing a controller from the network

c. Re-addressing existing controllers

d. Modifying existing programming

e. Changing device BBMD settings

f. Altering router tables

g. Altering BBMD tables

h. Altering foreign device settings

3. Where possible when adding new devices, the new internetwork segment(s) shall be isolated and screened for proper configuration prior to being added to the existing internetwork.

4. After new devices, networks, programming modifications, or configuration settings have been added to the existing network, network diagnostics must be performed and documented to ensure that the changes have not adversely affected the system. Any changes found to be having negative effects shall be reported to The Owner and immediately reverted until such time that the issue can be resolved. Resolution of the issue shall be coordinated with The Owner to minimize the impact to facility operations.

F. BACnet Device Object ID Parameters:

1. BACnet permits the interconnection of up to 4,194,303 devices.

2. Each device is referenced by its device Object_ID property.

3. Each device shall have a value for the Object_ID property that is unique across The Owner’s facilities, including existing devices.

4. No device shall have an Object_ID with an instance number less than 1000.

5. No device shall have an Object_ID with an instance number greater than 3,999,999.

6. Device Object_ID parameters shall be obtained from The Owner through the RFI process as outlined in the Change Control Process.

G. BACnet Network Number Parameters:

1. The BACnet permits the interconnection of up to 65,535 networks.
2. Each network must have a Network Number that is unique across The Owner's facilities, including existing networks.
3. No network shall have a Network Number less than 1000.
4. Network Number 65,535 shall not be used.

H. BACnet MS/TP MAC Addressing:

1. Master devices use token-passing.
2. Slave devices reply to requests only. They do not support the Who-is? service and therefore cannot be automatically discovered.
3. MS/TP (Master Slave/Token Passing) addressing consists of 256 (0-255) MAC addresses:
   a. 0 shall be reserved for the BACnet Router (B-RTR) serving the MS/TP segment.
   b. 0-127 may be used for master or slave devices.
   c. 128-254 are reserved for slave devices only.
   d. 255 is reserved for broadcasting.
4. MS/TP networks shall be limited to 32 devices to prevent network latency.
5. MAC addresses on a network shall be consecutive starting with 0 (B-RTR). (Some products reserve addresses 0, 1, 2 & 3. In cases like this, the addresses shall be consecutive once they begin.
6. The "Max Master" parameter for all applicable devices associated with an MS/TP network shall be set to the address of the highest-addressed master device.

1.9 COMMUNICATIONS

A. Wireless devices are not permitted, except in circumstances where the facility is listed as a historical building and wiring cannot be routed as required to complete the scope of work. All wireless device exception requests shall support mutual TLS and be submitted in writing and the final decision shall be at the discretion of The Owner only.

B. Cellular devices, such as meters located in remote areas, shall be allowable in limited capacities if necessary, due to wiring constraints, and with approval from The Owner. Cellular devices are not permitted within building structures.

C. BACnet/Ethernet is not permitted, and this functionality must be disabled prior to connection to any The Owner network.

D. Proprietary protocols, including JCI N2 and Siemens P1/P2 protocols, are not permitted on new projects. On partial renovation projects, where existing communication infrastructure already includes and requires existing trunks to be maintained, JCI N2 and Siemens P1/P2 protocols shall only be allowable for the purpose of keeping the integrity of the existing network intact for continued communication to existing devices. Projects that fall into this category shall have further approval from The Owner following communication from The Controls Contractor around project plan to ensure all communication remains intact upon project completion.

E. LonWorks-protocol devices are in no way compatible with BACnet devices. LonWorks/LonTalk/LON is not permitted.

1.10 CONDUCTORS AND CABLES FOR INTEGRATED AUTOMATION

A. Cabling & Installation:

1. Refer to Division 27 for details; that document shall supersede this document in all requirements regarding telecommunications design. The following additional requirements specific to Smart Building Technology Systems shall apply where they do not contradict Division 27.

2. All work shall comply with codes and standards applicable to each type of work through the course of this contract. Contractor shall also comply with the requirements of Facilities Standards.
3. Cabling installed in accessible plenum areas shall be installed in cable tray or shall be supported independently of other equipment, piping, or conduit in the space. Cable must not be supported from drop ceiling support structure wires and ran in a workman like manner parallel with the building lines. Plenum cabling shall not interfere with accessibility to other equipment.
4. All work shall be coordinated with The Owner property and facility managers. Conduit or other appurtenances that are required by The Owner facility management (regardless of codes or standards) shall be provided and installed by cabling installer.
5. Cabling shall be plenum-rated where installed without conduit.
6. Cabling installed underground shall be waterproof and rated for direct burial. All underground cabling shall be in conduit. Anywhere that cabling might be exposed to sunlight, UV-protected cabling shall be used. All cabling shall be of a type appropriate for the specific application and installation circumstances.
7. Core-drilling and other cabling pathway-creating activities shall be included where necessary. All penetrations thru fire walls shall be properly sealed per all national and local codes requirements.

B. Ethernet Cabling for Operational Technology Networks:

1. Transmission Medium: 1000BASE-T Ethernet CAT-6A (minimum).
2. All IP network cabling and cabling installation shall meet or exceed The Owner specifications and standards. Cabling shall be installed by Controls Contractor from OT devices to locations designated by The Owner as managed IP switch locations (data closets). All IP cabling shall be installed with adequate service loops (at least 2 feet) in designated IP switch locations to facilitate connection to The Owner patch panels or IP switches regardless of IT rack or switch installation configuration. Coordinate with The Owner to identify locations of The Owner network switches (existing or future), risers, raceways, and cabling trays.
3. All IP connections shall be direct between a device and an The Owner managed IP switch. Private IP subnetworks are not permitted.
4. Maximum length of Ethernet drop = 294 ft.
5. Ethernet cables shall be terminated with standard RJ-45 connectors.
6. Ethernet cables shall be tested and certified by the installer, with a report provided as part of the closeout documentation. The report shall indicate each individual cable identifier, origin, destination, length, and test result. Ensure installation is complete with no damage to outer jacket.

C. Low Voltage Connections in Electrical Equipment

1. Low voltage connections such as ethernet connections, serial communication trunks, fiber optic connections or any other communication system wiring shall never be made directly within any enclosure containing voltage in excess of 30 Volts.
2. Any low voltage connection that needs to enter a high voltage enclosure must have a patch panel, segregated low voltage cabinet, or other means of access for connection/disconnection without exposing the high voltage portion of the enclosure.
3. Any high voltage connections to UPS devices for low voltage systems shall also be accessible without needing to open up a high voltage enclosure. Hardwiring of this power wiring directly within a high voltage enclosure is prohibited, and the installer must provide a separate enclosure or segregated low-voltage section with a power outlet so that the UPS can be replaced without needing an electrician.

D. Cabling for serial networks:

1. Transmission Medium: Manufacturer-recommended gauge, twisted shielded pair, low capacitance, tinned, stranded cable with an orange jacket.
2. For underground installations, use the same electrical specifications as above, but provide waterproof cabling rated for direct burial. All underground cabling shall be in conduit.

E. Fiber Optic Cabling

1. See Division 27 for details regarding the selection and installation of fiber-optic cables. Fiber-optic cables and connectors shall be specified by The Owner's IT personnel per the specific circumstances of the project.

1.11 QUALITY ASSURANCE FOR NETWORK CONFIGURATION

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. Splices in communication cabling shall not be allowed. Under circumstances where underground cabling must be converted to plenum cable inside the building envelope, The Owner shall provide written approval and there shall be clear indication of these instances on project as-built documentation.

G. Refer to *25 00 00 Integrated Automation* and *25 05 00 Common Work Results for Integrated Automation* for additional quality assurance requirements.

1.12 SECURITY REQUIREMENTS

A. Single-Sign-On (SSO) shall be enabled wherever it is supported. Work with The Owner's ICT team to set up SSO.

B. Each operational technology software user from The Owner's team shall receive a unique username and password. The user shall be prompted to reset the password upon the first log in and shall be set to a minimum of 16 characters including alphanumerical and special characters *, &, <, >, #, (), !.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 PROJECT EXECUTION

A. Existing Conditions

1. Verify existing conditions before starting work. Report issues in writing to The Owner prior to making alterations to the existing system.
2. Verify that IP network infrastructure is available and/or coordinated with The Owner prior to starting work.
3. Coordination with The Owner is required to avoid or plan for potential system disruption. A risk and impact assessment must be performed prior to any activity that might disrupt existing system functionality. System outages must be planned at least two (2) weeks prior to work being performed.
    a. Activities that may impact existing system performance include (but are not limited to):
        i. Adding a new controller to the network
        ii. Removing a controller from the network
        iii. Re-addressing existing controllers
        iv. Modifying existing programming
        v. Changing device BBMD settings

vi. Altering router tables

vii. Altering BBMD tables

viii. Altering foreign device settings

4. Verify that conditioned power supply is available to the control units and to the operator workstation. Verify that field end devices & wiring is installed prior to installation proceeding.

B. Installation

1. Install control units and other hardware in position on permanent walls where not subject to excessive vibration. Terminal unit controls shall be installed in an enclosure integral to the terminal unit.
2. Install controllers and other OT components in locations and circumstances where they can easily be physically accessed for service. Avoid installation locations where obstacles exist that might hinder access, or where access to the space is restricted either physically or by policy. Avoid installation locations in lab spaces or other sensitive areas.
3. Where existing cable management systems are not in place, install and support cabling as required by The Owner standards and specifications.
4. Install software in control units and on the enterprise server. Implement all features of programs to specified requirements and appropriate to the sequence of operation shown on plans.
5. Provide conduit and electrical wiring in accordance with Division 26. Electrical material and installation shall be in accordance with the appropriate requirements of Division 26. Coordinate with Electrical Contractor for power requirements and locations.

C. New Construction

1. All building and equipment controllers shall be BACnet/IP for mechanical systems and shall reside on the WAN using IP network configuration parameters provided by The Owner. (A building controller is a device that controls a central plant, large air handling, or other major equipment; or provides supervisory control.)
2. Application controllers may use BACnet MS/TP networks. (An application controller is a device that controls terminal equipment or minor equipment, such as VAV terminal units).
3. All point names shall be approved by The Owner and shall be supplied with the correct standard units.

D. Mechanical Retrofit

1. All new building and equipment controllers shall be BACnet/IP and shall reside on the WAN using IP network configuration parameters provided by The Owner. Existing enclosures may be reused. (A building controller is a device that controls a central plant, large air handling, or other major equipment; or provides supervisory control.)
2. New application controllers may use BACnet MS/TP networks. Existing application controllers may use a proprietary protocol only if any/all points in the application controllers are available using BACnet (must support BIBBs: DS-RP-B, DS-WP-B, DM-DDB-B, DM-DOB-B, DM-DCC-B, DMRD-B). (An application controller is a device that controls terminal equipment or minor equipment, such as VAV terminal units.
3. All point names shall be approved by The Owner and shall be supplied with the correct standard units.
4. Where serial networks are eliminated, the old wiring shall be demolished.
5. Where other hardware, wiring, enclosures, or other physical infrastructure is no longer required as a result of the modifications, it shall be demolished.

E. System Upgrade

1. The contractor shall make all existing system point values accessible to BACnet/IP services for mechanical systems.
2. Upgrade software/firmware on modern building and equipment controllers to make them BACnet/IP-compliant where applicable or provide new BACnet/IP-compliant controllers. (A building controller is a

device that controls a central plant, large air handling, or other major equipment; or provides supervisory control.)

3. Replace all application controllers where required to allow full functionality of BAS. (An application controller is a device that controls terminal equipment or minor equipment, such as VAV terminal units.)
4. The contractor shall verify system configuration and conditions prior to beginning the retrofit/upgrade work with assistance from The Owner. This shall include at minimum:
    a. Point values and status
    b. Log/trend definitions
    c. Schedule configuration
    d. Point definitions
    e. Graphics/ Visualizations
    f. Sequence program logic
    g. Point alarming configurations
    h. Summary of all instances where objects or programs residing in the affected controller(s) interact with other controllers, devices, or systems.
5. System configurations including but not limited to point, alarm, log/trend, and schedule definitions shall be replicated in the upgraded system to provide equivalent functionality (at minimum). Sequence of Operations (SOO) shall be reviewed within the existing panel programs and provided to The Owner for review and approval for implementation. Programming functionality shall be replicated to meet the requirements of the approved SOO.
6. The contractor shall, where applicable, reconfigure communication parameters for existing devices of the same make as the products used to accomplish the retrofit/upgrade.
7. The contractor shall, where possible using the device's existing hardware and software, reconfigure 3rd-party application network devices for BACnet MS/TP where BACnet is an available option for the device and the serial network is not shared with proprietary devices. BACnet parameters will be specified by The Owner. The existing proprietary serial network shall be converted to BACnet MS/TP, and the device shall be connected to the MS/TP network.
8. The contractor shall, where possible using the device's existing hardware and software, reconfigure 3rd-party application network devices for BACnet/IP. BACnet parameters will be specified by The Owner. The device shall be connected to a LAN connection (provided by The Owner).
9. Depending on the terms of the contract, all point names shall be approved by The Owner and shall be supplied with the correct standard units.
10. Where serial networks are eliminated, the old wiring shall be demolished.
11. Where other hardware, wiring, enclosures, or other physical infrastructure is no longer required as a result of the modifications, it shall be demolished.

F. System Modification

1. System as-built documents shall be updated to reflect any changes made. The addition, modification, or removal of hardware that involves changes to network connectivity, addressing, or other managed parameters must follow The Owner processes and procedures outlined here or elsewhere.
2. Where serial networks are eliminated, the old wiring shall be demolished.
3. Where other hardware, wiring, enclosures, or other physical infrastructure is no longer required as a result of the modifications, it shall be demolished.

G. Service/Repair

1. System as-built documents shall be updated to reflect any changes made. The addition, modification, or removal of hardware that involves changes to network connectivity, addressing, or other managed parameters must follow The Owner processes and procedures outlined here or elsewhere.
2. Where serial networks are eliminated, the old wiring shall be demolished.
3. Where other hardware, wiring, enclosures, or other physical infrastructure is no longer required as a result of the service or repair, it shall be demolished.

H. Maintenance

1. System as-built documents shall be updated to reflect any changes made. The addition, modification, or removal of hardware that involves changes to network connectivity, addressing, or other managed parameters must follow The Owner processes and procedures outlined here or elsewhere.
2. Where serial networks are eliminated, the old wiring shall be demolished.
3. Where other hardware, wiring, enclosures, or other physical infrastructure is no longer required as a result of the maintenance activities, it shall be demolished.

I. Selective Demolition for Integrated Automation

1. Any existing BAS cabling intended to be no longer in use following the installation of new cabling shall be removed (demolished) as a part of the project.
2. Existing cabling to be demolished shall be shown on the plans and schematic diagrams. Separate demolition plan sheets and schematic diagrams shall be provided for projects with extensive cable demolition.
3. The Designer shall include requirements in the design that are clear and precise such that the Contractor will meet Code requirements and achieve The Owner's objectives. The instructions shall include, but not be limited to the following:
    a. Notations to indicate items to be salvaged to The Owner.
    b. Hatched over-marking on items to be demolished.
    c. Requirements to properly and legally dispose of demolished materials, without additional cost to The Owner.

J. Requirements that the Contractor properly tag existing cabling that is intended to remain for future use, avoiding the potential determination by Code officials that an untagged cable has been abandoned and would therefore be subject to removal.

3.2 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 may lie on a local VLAN. These existing legacy components shall remain as is unless otherwise specified by The Owner.

F. New building automation IP devices shall be capable of DHCP.

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 in all areas for all applications.
   b. BACnet MS/TP is permitted in limited capacity. See section 1.3 for details.
2. Modbus
   a. Modbus TCP
   b. Modbus RTU in limited capacity including electrical metering and monitoring.
3. Tridium FOX/FOXS
4. HTTP/HTTPS

3.3 CONTROL AND MONITORING OF NETWORK COMMUNICATION

A. Any new IP device shall have their ethernet protocol disabled prior to installation ontoThe 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, butare 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 rooftop units.

D. 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.

3.4 IDENTIFICATION FOR INTEGRATED AUTOMATION

1. Panels & Enclosures
   a. All OT Enclosures shall be clearly labeled with a black micarta or lamacoid nameplate on the panel cover indicating the panel name. Labels shall be engraved with white lettering.
   b. Any terminal strip shall be clearly labeled identifying which point on the controller and which field device each terminal is associated with.
   c. Handwritten labels are strictly prohibited for any OT labeling.
   d. Company name and service phone number shall be provided on external or internal surface of the enclosures.
   e. Labeling material quality shall outlast the life expectancy of devices and panels. The Controls Contractor shall ensure that all labels are rated for the applicable environment in which they reside.
   f. Any associated J-boxes shall be clearly labeled.
2. OT Network Cabling
   a. Ethernet Cabling: BACnet/IP network cables shall have an orange jacket. Label each cable end to clearly indicate the device that the cable plugs into as well as the location and identity of the other end. Provide permanent labels that will stay securely affixed and legible throughout the life of the equipment.

b. MS/TP Cabling: BACnet MS/TP network cables shall have an orange jacket. Label each cable end to clearly indicate the device that the cable plugs into as well as the location and identity of the other end. Provide permanent labels that will stay securely affixed and legible throughout the life of the equipment.

c. Modbus Cabling: Modbus network cables shall have an orange jacket. Label each cable end to clearly indicate the device that the cable plugs into as well as the location and identity of the other end. Provide permanent labels that will stay securely affixed and legible throughout the life of the equipment

3. Input/Output Wiring
   a. All Input/Output wiring & terminal blocks associated to input and output wiring to and from a controller shall be labeled. Provide permanent labels that will stay securely affixed and legible for the life of the equipment.

   b. At the controller, each wire shall be labeled with the termination address at the panel in a way that coordinates with the associated engineered drawing set that is located in the panel. The user should be able to re-connect all wiring to the appropriate location based on the wire labeling and associated drawings located in the panel.

   c. At the end device, each wire shall be labeled with the termination address that the wire connects back to at the panel in a way that coordinates with the associated engineered drawing set that is located in the panel. The user should be able to identify where each wire is located on the drawing set based on the label.

4. Each control, regardless of type, will be provided with a storage panel in which the device will be placed along with the current engineered drawing set for that panel.
   a. All wiring diagrams and point designations will be included as well as a plan drawing of the panel.

   b. All I/O will be clearly labeled consistent with The Owner requirements and matched across the entire project.

   c. All I/O markings will be identifiable on the controller.

   d. Any terminal strip will be keyed with a specific drawing identifying which point on the controller and which field device each terminal is associated with.

   e. Clear descriptions of I/O will be verified prior to identification implementation.

END OF SECTION

SECTION 25 06 00 – SCHEDULES FOR INTEGRATED AUTOMATION

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the requirements for schedules for integrated automation devices.

B. Related Sections:

1. *25 00 00 Integrated Automation*
2. *25 01 00 Operation and Maintenance of Integrated Automation*
3. *25 05 00 Common Work Results for Integrated Automation*
4. *25 08 00 Commissioning of Integrated Automation*
5. *25 11 00 Integrated Automation Network Devices*
6. *25 14 00 Integrated Automation Local Control Units*
7. *25 15 00 Integrated Automation Software*
8. *25 35 00 Integrated Automated Instrumentation and Terminal Devices for HVAC*
9. *25 36 00 Integrated Automation Instrumentation and Terminal Devices for Electrical Systems*

1.2 REFERENCES

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

1.3 ACRONYMS

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

1.4 DEFINITIONS

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

1.5 SYSTEM DESCRIPTION

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

1.6 SUBMITTALS

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

1.7 GENERAL SCHEDULE REQUIREMENTS

A. Device Schedule: A device schedule including data for all OT network devices shall be submitted. The contractor shall submit the schedule containing all information listed below in order to obtain the IP address & BACnet instance numbering information for each device.

1. For all BACnet devices, the contractor shall submit the following:
    a. Controller description
    b. Manufacturer
    c. Model number
    d. Hardware MAC address(es) (12-character hexadecimal hardware address)
    e. BACnet device type (i.e.: B-BC, B-AAC, B-ASC, etc.)
    f. BACnet network type (BACnet/IP or BACnet MS/TP)
    g. Application software version
    h. Firmware version

i. Controller installation location

j. Controlled equipment

k. MS/TP network(s) supported (for BACnet routers, where applicable)

l. Host controller (for MS/TP devices, where applicable)

2. In response to this submittal, The Owner shall provide the following information as required for IP based & MS/TP based equipment:

   a. IP Address

   b. Subnet Mask

   c. Default Gateway

   d. UDP Port

   e. BACnet Device ID

   f. BACnet Network #

   g. BBMD Information

   h. MS/TP MAC Address

   i. Network Switch ID and Physical Location

   j. Network Switch Ports and Associated Device(s)

3. For all Modbus devices, the contractor shall submit the following:

   a. Controller description

   b. Manufacturer

   c. Model number

   d. Hardware MAC address(es) (12-character hexadecimal hardware address)

   e. Device type (i.e.: B-BC, B-AAC, B-ASC, etc.)

   f. Application software version

   g. Firmware version

   h. Controller installation location

   i. Controlled equipment

   j. RTU Network

   k. RTU network(s) supported (where applicable)

4. In response to this submittal, The Owner shall provide the following information as required for IP based & RTU based equipment:

   a. IP Address

   b. Subnet Mask

   c. Default Gateway

   d. TCP Port

   e. RTU Address

   f. Network Switch ID and Physical Location

   g. Network Switch Ports and Associated Device(s)

B. Object Naming Schedule: All system object names shall be submitted.

1. All BACnet-discoverable objects shall conform to the standard. No exceptions will be permitted.
2. Object Types include:
    a. Devices
    b. Control points (physical and virtual)
    c. Alarm notification classes
    d. Equipment schedules
    e. Trend logs
    f. Any other object that is discoverable on the BAS network
    g. Any data point that is intended to be displayed on The Owner's Graphics User Interface
3. Each object in the schedule shall include the following:
    a. Existing Object Name (If applicable)
    b. New Object Name
    c. Object Description
    d. Object Type
    e. Engineering Units
    f. Trend Log (Change of Value or time interval)

C. Computerized Maintenance Management System (CMMS) Schedule: A CMMS Submittal shall be submitted for all building automation controllers, gateways, routers, and other IP connected devices furnished as a part of this project.

1. The contractor shall be responsible for providing the following information for each piece of equipment in the schedule:
    a. Manufacturer
    b. Model Number
    c. Serial Number
    d. Equipment Status
    e. Campus
    f. Building Name
    g. Building Number
    h. Floor
    i. Room Type
    j. Location Description

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 NOT USED

END OF SECTION

SECTION 25 08 00 – COMMISSIONING OF INTEGRATED AUTOMATION

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the requirements for the commissioning of integrated automation systems.

B. Related Sections:

1. *25 00 00 Integrated Automation*
2. *25 01 00 Operation and Maintenance of Integrated Automation*
3. *25 05 00 Common Work Results for Integrated Automation*
4. *25 06 00 Schedules for Integrated Automation*
5. *25 11 00 Integrated Automation Network Devices*
6. *25 14 00 Integrated Automation Local Control Units*
7. *25 15 00 Integrated Automation Software*
8. *25 35 00 Integrated Automated Instrumentation and Terminal Devices for HVAC*
9. *25 36 00 Integrated Automation Instrumentation and Terminal Devices for Electrical Systems*

1.2 REFERENCES

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

1.3 ACRONYMS

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

1.4 DEFINITIONS

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

1.5 SYSTEM DESCRIPTION

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

1.6 SUBMITTALS

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

1.7 GENERAL COMMISSIONING DESCRIPTION

A. Commissioning is a quality-focused process for achieving, verifying, and documenting that building systems are installed and perform functionally as intended according to The Owner's Project Requirements, Basis of Design, and the requirements of the contract and design documents.

B. The work includes the completion and documentation of formal commissioning procedures by the GC, Trade Subcontractors, including The Controls Contractor, and Manufacturer Representatives.

1. The GC and Trade Subcontractors shall provide the quality control for the installation, startup, checkout and testing of the systems. The commissioning process provides independent review by the CxA throughout the process and qualitative functional performance testing witnessed by the CxA in order to formally observe and document the quality control efforts are completed.

2. The Trade Subcontractors and the Manufacturer Representatives shall be responsible for participation in the commissioning process as outlined in this specification.

C. Commissioning during the construction phase is intended to achieve the following specific objectives:

1. Commissioning review of the Trade Subcontractor submittals for systems to be commissioned, concurrent with the Design Professional's review.
2. Finalize the Cx Plan including project specific checklist and test forms.
3. Verify the applicable equipment and systems are installed according to the design documents, manufacturer's recommendations and to industry-accepted minimum standards, and that they receive the required operational checkout and testing by the Trade Subcontractors.
4. Verify and document proper performance of equipment and systems through execution of pre-functional checks and functional performance tests.
5. Verify The Owner's facilities and operations personnel and building occupants are trained according to contract document requirements.
6. Prepare the commissioning report and documentation.

D. Commissioning during the post-occupancy, warranty phase is intended to achieve the following specific objectives:

1. Perform any necessary seasonal, deferred testing, or trend analysis to be defined in the Cx Plan.
2. Review the system operations with the O&M staff, and any open or new Cx issues and recommendations with the commissioning team members, within 10 months of substantial completion (and no later than 2 months prior to the end of the warranty phase).

E. Systems and equipment to be commissioned.

1. All new integrated automation controls and devices including new valves, actuators, sensors, meters and any applicable TAB and sensor calibrations.
2. Existing HVAC and Electrical systems commissioning will only involve testing of the systems as part of the OT upgrades and integration, and any applicable TAB per the owner's request (for example, balancing downstream of VAV or induction boxes).
    a. Testing of existing systems may expose existing issues that are not the responsibility of The Controls Contractor.
3. Process equipment is not included in the commissioning scope of work.

1.8 CONTROLS CONTRACTOR RESPONSIBILITIES

A. In addition to the general Trade Subcontractor responsibilities outlined above, the Controls Contractor responsibilities during commissioning shall also include, but are not limited to, the following:

1. Submit a controls installation verification & PFC Plan with Blank Forms, for review by the CxA, at least 4 weeks in advance of performing any control-related controls installation verification and PFC tasks. The plan and forms shall include:
    a. Installation verification of the control input and output points (sensors, actuators, relays, etc.) to verify all points have been installed per the points list and the physical installation of each point has been verified.
    b. Control system program setup checks, e.g., point type, range/scale.
    c. Point-to-point checks with the operating system software graphics or local controller display interface or graphics, by point type: AO, AI, BO, BI.
        i. In the Plan, the Controls Contractor shall provide a written process as to how they are going verify and check each point type (AO, AI, BO, BI).

d. Sensor accuracy checks or calibration results:

i. For analog input sensors that are factory calibrated (no field calibration is required per the Specifications), the control system program setup (as noted above) shall be verified and recorded in the PFC forms for all sensors, and all sensor readings on the graphics or local controller display shall be recorded on the PFC forms and shall be checked by verifying the reading is within the expected range. Sensor readings that are questionable or outside the expected range shall be checked by the Controls Contractor using a hand-held sensor of equal accuracy.

ii. For sensors that require field calibration, follow the manufacturer requirements for calibration, and record the calibration results in the PFC forms, including any readings using a hand-held sensor of equal accuracy.

e. Actuator checks:

i. At a minimum, all actuators shall be physically checked at commanded full open position (100% open), commanded half-open position (50% open), and commanded fully closed position (0% open) and documented on the PFC forms.

f. Verification of all local equipment control points integrated to the OT system via network interface communications (e.g., BACnet, Modbus, etc.), including both read only and writable points.

2. The Controls Contractor shall configure all local control graphics and programming logic for the sequence of operations and associated setpoints, schedules, and alarms and verify the system operation, including testing and completing the control loop tuning, prior to starting FPTs.

3. Prior to conducting the FPTs, meet with the CxA to review the programmed sequences of operation and sample system graphics with the CxA.

a. The lead programmer from the Controls Contractor shall be in attendance.

b. The intent of this requirement is to reduce field testing time by reviewing with the CxA the actual programmed sequence logic and graphics relative to the approved submittal and sequences, in order to confirm the actual programming and graphics prior to field testing, and to allow for any changes and adjustments.

c. The meeting duration time is estimated to not be more than 1 day in duration.

4. Prior to conducting the CxA witnessed FPTs, place the systems and controls into the operating modes intended for testing. Check all control system safety cutouts, alarms, and interlocks with smoke control and fire-life safety during each mode of operation prior to functional testing. Ensure all systems are operating and performing per the requirements of the contract and design documents, and have been pre-tested per the FPTs, and are ready for the CxA witnessed FPTs.

a. The Trade Subcontractors shall determine the appropriate level of pre-testing, to prepare for the CxA witnessed FPTs.

5. The Controls Contractor shall provide any necessary control system global or system level commands and setpoint adjustments necessary to conduct the testing as called out in the FPT procedures.

6. The Controls Contractor shall set up the appropriate trends per the Trend Setup Verification forms provided by the CxA and shall provide trend data into a usable electronic format file, such as a text, CSV, or Excel format, to the CxA. The CxA will analyze and review the trend data as part of the FPT. These trends shall be setup prior to conducting any sequence of operation functional tests.

a. The trend points list may include both hardware (inputs, outputs) and virtual / software points.

b. The appropriate trend intervals and minimum duration will be provided by the CxA either in a Trend Setup Verification form or in the FPT forms.

c. As an option approved by The Owner, the Controls Contractor may provide the CxA remote access to the control system, with permission from The Owner, that will allow the CxA to easily and directly download the trend data files.

7. The Controls Contractor shall also provide trend data to the CxA during the post- occupancy warranty phase for review by the CxA, where required.

1.9 INTEGRATED AUTOMATION SYSTEM COMMISSIONING

A. BACnet Parameter Commissioning & Acceptance

1. BACnet Parameter Commissioning

a. To ensure that all BACnet parameters have been configured correctly, each new device must be certified to have the parameters submitted and approved prior to project execution. Additionally, the BACnet internetwork must be free from errors; after all work has been completed, the vendor must submit a diagnostic report that reflects a properly functioning BACnet internetwork. (If the vendor wishes to produce a diagnostic report prior to beginning work to establish a baseline of network performance and errors, this can be coordinated with The Owner. If no baseline is established, the network shall be assumed to be error-free at the outset of the project.)

b. All BACnet networks shall be configured for maximum performance.

c. BACnet Devices & Objects shall be discoverable from any BACnet Client or other capable BACnet device regardless of manufacturer. All discovered devices and objects shall transmit all properties requested (where available). All requested properties shall be transmitted in their entirety, including all characters; object names, etc. shall not be truncated.

d. All objects shall have plainly worded descriptions (not the same as the Object Name property).

e. All objects shall have correct and uniform engineering units. All engineering units are subject to review and approval from The Owner.

f. BACnet PICS must be submitted for each device model supplied as part of the project. All new devices shall be BTL-listed. The specific model and firmware version shall be BTL-listed.

g. The Owner reserves the right to use a third-party contractor or service of its choosing to evaluate and commission the BACnet configuration and may reject the system based on the recommendations of that third-party.

B. Modbus Commissioning & Acceptance

1. Modbus Register Commissioning

a. To ensure data integrity, the Controls Contractor shall conduct testing. A sample of physical measurements shall be taken on site and confirmed with data at the Modbus registers. Data shall be verified to be accurate and representative of real data within the previous 5 seconds.

b. Modbus register maps shall be provided for all Modbus devices.

C. Manufacturer's Field Services

1. Start and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.

2. Ensure that all Test and Balance (TAB) and Commissioning (Cx) values (calibrations, setpoints, coefficients, etc.) are captured in each controller and backed-up. Lost TAB or Cx values shall be the responsibility of the Controls Contractor to re-implement.

3. All work shall comply with codes and standards applicable to each type of work through the course of this project.

4. The Controls Contractor bears the responsibility of providing, configuring, and deploying network (IP, BACnet, and Modbus) devices in a manner conducive to a properly operating, error-free internetwork. Any device causing or thought to be causing network disruption shall be removed from the network until such time that the Controls Contractor can determine the cause of the issue and provide resolution.
5. After new devices, networks, programming modifications, or configuration settings have been added to the existing network, network diagnostics must be performed and documented to ensure that the changes have not adversely affected the system. Any changes found to be having negative effects shall be reported to The Owner and immediately reverted until such time that the issue can be resolved. Resolution of the issue shall be coordinated with The Owner to minimize the impacts to facility operations.
6. Provide service engineer to instruct The Owner representative (Operation & Maintenance contractor) in operation of systems plant and equipment for period specified in contract documents.
7. Provide operator training on data display, alarm, and status descriptors, requesting data, execution of commands and request of logs. Include hours of dedicated instructor time as specified in contract documents. Provide training on site. For additional training requirements refer to 25 00 00.

D. Demonstration and Instructions

1. Demonstrate complete, operating, error-free system to The Owner and/or The Owner representative. Also demonstrate to the test and balance contractor (TAB), and third-party commissioning (Cx) agent as required to complete TAB and Cx activities. Cooperate with TAB and Cx contractors to resolve BAS issues promptly.
2. Refer to 25 00 00 for Owner training requirements.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 MEETINGS, SCHEDULING AND COORDINATION

A. When commissioning team member attendance is required, as determined by the CxA and GC, team members shall be punctual and attentive during the meeting.

B. The CxA will conduct a commissioning kick-off meeting, usually within 60 days of the commencement of construction. All team members involved in the commissioning process shall attend the kick-off meeting.

C. The CxA will plan other commissioning meetings as deemed necessary as construction progresses. These meetings will cover planning and coordination, Cx tasks and documentation, and Cx issues resolution.

D. The frequency of meetings will vary through construction but generally increase during startup and commissioning activities.

E. The CxA will write and distribute meeting minutes documenting the meeting discussion, conclusions, and actions for each team member.

3.2 DOCUMENTATION

A. The Trade Subcontractors have specific responsibilities for assisting in the development of equipment check, test and verification procedures and forms, and in performing and documenting commissioning tests, as directed by the GC and as overseen by the CxA.

B. The Trade Subcontractors shall provide, wherever the Contract Documents require, system checks and testing, test reports, factory test data and reports, checklists, operational verifications, and demonstration, etc., whether specified or not in the commissioning sections.

3.3 TEST EQUIPMENT

A. The Trade Subcontractors shall provide all test equipment in sufficient quantities to execute all Pre-Functional and Functional Performance Tests in an expedient fashion.

B. The test equipment shall be of industrial quality and suitable for testing and calibration with accuracy within the tolerance necessary to demonstrate system performance per the Contract Documents. If not otherwise specified, the following minimum requirements apply:

C. Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution to ±0.1°F.

D. Pressure sensors shall have an accuracy of ±2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

E. The test equipment shall have calibration certification per equipment manufacturer's interval level or within one year if not otherwise specified. The calibration tags shall be affixed or certificates readily available for all test equipment.

3.4 PRE-FUNCTIONAL COMMISSIONING ACTIVITIES

A. The Trade Subcontractors shall conduct all startup procedures and tests without compromise to human or equipment safety. The GC and Trade Subcontractors shall be responsible for the liability and safety of conducting all startup, checks and tests.

B. The Trade Subcontractors shall clearly identify and list any issues and deficiencies resulting from the installation verification, Startup and PFC tasks on the associated forms and immediately notify the CxA. The CxA will additionally document the issues on the Cx Log. Once issues and deficiencies are corrected and verified, the associated forms shall be updated and resubmitted, and any necessary field review, back-checks or re-tests witnessed by the CxA.

C. The GC and Trade Subcontractors shall provide a minimum 10 business days' notice to the CxA for witnessing equipment Startup and PFC tasks.

D. For the integrated automation Pre-Functional Checks and for the TAB, the CxA will witness a Field Verification of each, as described in Part 1, Paragraph 1.8.

E. The GC and Trade Subcontractors shall ensure the completion of the installation verification, Startup and PFC forms. Review and approval of the completed installation verification, Startup and PFC forms by the CxA is required prior to conducting the FPTs.

3.5 FUNCTIONAL PERFORMANCE TESTS

A. The Trade Subcontractors shall perform all FPTs per the final FPT forms, for all systems and equipment in the scope of commissioning. The FPTs shall be witnessed by the CxA. The Trade Subcontractors may need to complete off-hours or weekend work in order to complete the FPTs. The CxA will document all testing results on the FPT forms.

B. As outlined in the Part 1, a sampling approach shall be used for the FPTs of identical systems and equipment, using the sample rates as defined below and/or in the Cx Plan, with the specific systems and equipment selected by the CxA.

1. FPT Sample Rates for Terminal and Single-Zone Units: such as variable airvolume (VAV) boxes, fan coil units (FCUs), split DX units, etc.

    a. Detailed Sequence of Operation Tests for each unique unit type / sequence of operation (e.g., VAV with reheat, VAV cooling only, Induction Box, Unit Heater, etc.).

    b. Verification Tests and Performance Tests for approximately 10% to 20% of the units by type, as selected by CxA.

2. FPT Sample Rates for Miscellaneous Fans: such as stand-alone supply, exhaust, or transfer fans (excluding VAV kitchen exhaust fans), etc.

    a. Detailed Sequence of Operation Tests for each unique fan type / sequence of operation

(e.g., constant speed scheduled general exhaust fan, electrical room exhaust fan controlled based on temperature, interlocked constant speed exhaust fan, etc.).

b. Verification Tests and Performance Tests for approximately 50% to 100% of the fans by type, as selected by CxA.

3. FPT Sample Rates for Central, Multi-zonal Air-Handling Units (AHUs):

a. Detailed Sequence of Operation Tests for each unique AHU sequence of operation.

b. Verification Tests for 100% of the units.

c. An Integrated Systems and Performance Tests (with the VAV or Induction Box terminal units) for approximately 20% to 40% of the units by type as selected by CxA.

4. FPT Sample Rates for Central Plant Systems –, Heating Hot Water:

a. All Sequence of Operation and Verification Tests for each system in its entirety (no sampling).

b. An Integrated Systems and Performance Tests with the AHU and VAV or Induction Box with (airside) systems.

C. The Trade Subcontractors shall determine what level of pre-testing is appropriate in order to prepare for the CxA witnessed FPTs.

D. The GC and Trade Subcontractors shall coordinate all FPTs with the CxA and provide a minimum of 10 days' notice prior to conducting each test.

E. The GC and Trade Subcontractors shall have responsibility for the liability and safety of conducting all functional performance tests.

F. The Trade Subcontractor executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. to execute the test according to the test procedures.

1. The Trade Subcontractors shall provide any necessary control system global or system level commands and setpoint adjustments necessary to conduct the testing as called out in the FPT procedures. For example, globally adjusting the space temperature setpoints for all terminal units on a floor or AHU or the building. Or as another example, globally overriding the economizer status command for all AHUs.

G. At completion of the test, the Trade Subcontractor shall return all affected building equipment and systems to their pre-test normal condition.

3.6 TREND ANALYSIS

A. The CxA may conduct trend analysis as part of the FPT process, after completion of the onsite field conducted FPTs and correction of all issues and deficiencies, to verify integrated system operation and performance.

B. The CxA will prepare a BAS trend points list including the trend interval. The BAS Trade Contractor shall set up the trend log definitions prior to the start of the sequence of operation FPTs.

C. The BAS Trade Subcontractor shall provide the trend to the CxA in an electronic format, either a text file, CSV file or Excel file, with related system parameters grouped together. The estimated duration for the trend data is 1 to 3 weeks (with a minimum of 1 weeks' worth of data).

D. If the CxA discovers any control or performance issues during trend analysis, the Trade Subcontractors shall correct the issues and provide new trend data for analysis verification by the CxA.

3.7 COMMISSIONING ISSUES, BACK-CHECKS AND RE-TESTS

A. When Cx issues are identified during testing, the CxA will discuss with the executing Trade Subcontractor and/or GC and determine whether or not testing can proceed. The CxA may allow

immediate correction of minor issues and deficiencies identified during testing. The Cx issue and any identified resolution will be documented on the test form in use in addition to the Cx Log.

B. The CxA will maintain and update the Cx Log, and document the issue resolution process. Copies will be distributed to the GC, Owner, and Trade Subcontractors as appropriate. The Trade Subcontractors shall provide updates and comments regarding issue status and resolution.

C. The Trade Subcontractors shall promptly correct all Cx issues at no cost to The Owner within the contract scope. The responsible party shall correct the issue and inform the GC and CxA of the resolution and completion date and update the Cx Log accordingly (in the fields assigned for contractor updates).

D. The CxA will record completion on the Cx Log after a successful witnessed re-test, field review, back-check, verification obtained through appropriate documentation or photographs, or acceptance by the Design Professional or Owner. The GC shall reschedule any applicable re-testing with the CxA and Trade Subcontractor. The Trade Subcontractor shall retest until achievement of passing performance or Owner acceptance of the noted issue.

E. Where sampling is used for the PFCs and FPTs, the results shall be deemed acceptable once all noted issues are resolved and any new sample tests or checks have passed.

F. Additional parties may require input during a dispute regarding a Cx issue. Regardless of the validity or responsibility of the issue, the CxA will have the final interpretive authority on Cx issues, and The Owner will have the final approval authority.

G. The CxA may recommend solutions to Cx issues. However, the GC and Trade Subcontractors ultimately have the burden of responsibility to solve, correct, and perform required retests.

H. Back-checks, Verifications and Re-testing:

1. The CxA will witness one (1) re-test or will perform one (1) field back-check or verification of any Cx issue.

2. The CxA's total onsite time for re-test witnessing and field verification or back-check of Cx issues will be limited to no more than 1 workday per building (full 8-hour workdays) for all applicable systems in the commissioning scope.

3. The Owner may back-charge the GC for any additional fees from the CxA, resulting from any additional re-testing or field back-checks or verification beyond this allocated total time.

4. The GC must provide a minimum 48 business hours' notice for scheduling any re-testing, though the CxA will attempt to accommodate a shorter timeframe if feasible.

5. Any required re-testing shall not be considered a justified reason for a claim of delay or for a time extension.

6. For any re-testing required, the CxA will determine if the entire test must be re-tested or if it is acceptable to re-test specific portions of the test that had failed.

3.8 DEFERRED & SEASONAL TESTING

A. Before or during the end of the first-year warranty period, the Trade Subcontractor shall complete any seasonal or deferred testing, required per the design specifications and as defined in the Cx Plan. The Trade Subcontractors shall complete tests in the same manner as all other commissioning tests, including CxA witnessing.

1. For applicable projects, a seasonal integrated systems and performance test of the air-handing units hydronic heating system during lower ambient conditions may be required, depending on the conditions during the construction phase FPTs. Verify with The Owner to determine whether this will be a requirement for the project.

B. The GC and Trade Subcontractor shall coordinate with CxA and Owner and schedule all deferred and seasonal testing.

3.9 TRAINING VERIFICATION

A. The GC and Trade Subcontractors shall coordinate and schedule the training for The Owner's facility and operations personnel and building occupants. The GC shall ensure that training is completed per the requirements of the contract documents and specifications.

B. Trade Subcontractors responsible for specific equipment and system training shall submit to the GC, a written training agenda for each training class for the equipment and systems to be commissioned. The GC shall submit a comprehensive Training Plan, including the specific training agendas, to Owner, Design Professionals and CxA for review and approval.

C. The CxA will review the Training Plans for commissioning verification prior to conducting the actual training.

D. For verification of actual training conducted, the GC shall submit to CxA 'attendee signed' attendance sheets for each training session conducted and a copy of any final training presentations or handout materials.

E. Additional information regarding training requirements is available in 25 00 00.

3.10 COMMISSIONING ACCEPTANCE, CLOSE-OUT, AND REPORTING

A. Completion of the main commissioning activities (system readiness checks, functional performance testing, and training) shall be accomplished as a prerequisite for substantial completion. Completion of any re-testing shall be completed prior to final acceptance of commissioning.

B. After completion of the main commissioning activities and following review of the completed commissioning documents, test results and the current Cx Log with The Owner, The Owner will indicate whether they accept completion of the project construction phase commissioning or if not, the requirements for acceptance. Upon Owner acceptance, any remaining open Cx issues will be transferred to the warranty phase Cx Log for tracking resolution and completion as part of the warranty phase commissioning.

C. Upon completion of all commissioning activities, the CxA will prepare and submit to The Owner a Cx Report detailing all completed commissioning activities and documentation. The GC shall support this effort by providing all Trade Subcontractor commissioning documentation.

3.11 POST-OCCUPANCY WARRANTY PHASE COMMISSIONING

A. The Trade Subcontractors shall execute any defined seasonal or deferred FPTs, witnessed by the CxA.

B. The CxA may review trend data during the Warranty Phase. The Controls Contractor shall be responsible for providing post-occupancy trend data to the CxA.

C. The CxA will report any identified issues and recommendations to the GC via a Warranty Phase Cx Log for review and resolution by the GC and Trade Subcontractors prior to the end of the warranty period, for any issues or recommendations identified either by the CxA or The Owner. The GC shall work with the Trade Subcontractors and O&M staff to make corrections and adjustments as required to address the issues and recommendations.

D. Key representatives from the GC and Trade Subcontractors shall attend a near end of warranty commissioning review meeting, to be scheduled with The Owner's facility staff and the CxA, no later than either 10 months after substation completion or two months prior to the expiration of the first 12-month warranty period of building occupancy.

1. During this meeting, the operation of the systems will be discussed with The Owner's staff, the results of any commissioning trend analysis will be reviewed, and the Warranty Phase Cx Log will be reviewed. If needed, a walk-through of the systems with The Owner's staff will be conducted.

2. Next steps and actions items for any open Cx issues and recommendations will be discussed and documented via meeting minutes or a field report issued by the CxA. The intent is to resolve any open Cx issues prior to the end of the warranty phase.

E. After correcting noted Warranty Phase Cx issues, the GC shall notify the CxA, and the CxA will back-check and verify resolution of the issues and recommendations.

F. Issues identified during the warranty period will remain warranty phase Cx issues until satisfactory completion by Trade Subcontractors, even if the warranty period expires during the correction and back-check period.

END OF SECTION

SECTION 25 11 00 – INTEGRATED AUTOMATED NETWORK DEVICES

PART 1 - GENERAL

1.1 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 01 00 Operation and Maintenance of Integrated Automation*
3. *25 05 00 Common Work Results for Integrated Automation*
4. *25 06 00 Schedules for Integrated Automation*
5. *25 08 00 Commissioning of Integrated Automation*
6. *25 14 00 Integrated Automation Local Control Units*
7. *25 15 00 Integrated Automation Software*
8. *25 35 00 Integrated Automated Instrumentation and Terminal Devices for HVAC*
9. *25 36 00 Integrated Automation Instrumentation and Terminal Devices for Electrical Systems*

1.2 REFERENCES

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

1.3 ACRONYMS

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

1.4 DEFINITIONS

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

1.5 SYSTEM DESCRIPTION

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

1.6 SUBMITTALS

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

1.7 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 ofthe 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 Controls Contractor shall confirm compatibility between supervisory software and server hardware.

E. Any new BAS 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.

1.8 WARRANTY

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

PART 2 - PRODUCTS

2.1 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.

2.2 MANUFACTURED UNITS

A. Acceptable Manufacturers for BACnet Routers:

1. Distech Controls
2. Or Will County Approved Equal

B. Acceptable Manufacturers for BACnet Integration:

1. Distech Controls
2. Or Will County Approved Equal

2.3 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

2.4 BRIDGES

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

2.5 SWITCHES AND ROUTERS

A. Switches and 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 unless the device supports mutual TLS and has been approved by The Owner.

C. Any switches or 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.

2.6 INTEGRATORS

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

B. Integrators shall be configured as BACnet or Modbus devices. Data between multiple integrators must use the BACnet or Modbus 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 server 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

3.1 NETWORK COMMUNICATION REQUIREMENTS

A. For network communication requirements reference section *25 05 00 Common Work Results for Integrated Automation*

3.2 GENERAL INSTALLATION

A. For installation requirements, reference section *25 35 00 Integrated Automated Instrumentation and Terminal Devices for HVAC*.

3.3 INTEGRATORS

A. Any new Integrator installed on The Owner's network shall pass all data as BACnet objects over The Owner's IT 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 05 00 Common Work Results for Integrated Automation*.

END OF SECTION

SECTION 25 14 00 – INTEGRATED AUTOMATION FIELD DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the requirements for field level devices for The Owner's building management system.

B. Related Sections:

1. *25 00 00 Integrated Automation*
2. *25 01 00 Operation and Maintenance of Integrated Automation*
3. *25 05 00 Common Work Results for Integrated Automation*
4. *25 06 00 Schedules for Integrated Automation*
5. *25 08 00 Commissioning of Integrated Automation*
6. *25 11 00 Integrated Automation Network Devices*
7. *25 15 00 Integrated Automation Software*
8. *25 35 00 Integrated Automated Instrumentation and Terminal Devices for HVAC*
9. *25 36 00 Integrated Automation Instrumentation and Terminal Devices for Electrical Systems*

1.2 REFERENCES

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

1.3 DEFINITIONS

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

1.4 SYSTEM DESCRIPTION

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

1.5 SUBMITTALS

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

1.6 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.

1.7 WARRANTY

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

1.8 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

2.1 GENERAL PRODUCT REQUIREMENTS

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

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

C. Modbus TCP/IP shall be the default communication protocol for all new field controllers or meters on electrical or metering systems. Where building constraints prevent the use of Modbus TCP/IP, Modbus RTU is the preferred alternative communication protocol for field controllers.

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.

2.2 MANUFACTURED UNITS

A. Acceptable Manufacturers:

1. Distech Controls
2. Or Will County Approved Equal

2.3 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

2.4 PROGRAMMABLE DEVICES FOR HVAC

A. All physical and electrical requirements are referenced in section *25 35 00 Instrumentation and Terminal Devices for HVAC*.

B. Programmable controllers shall be BACnet Testing Laboratories (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 capable of DHCP but shall be set-up as static IP 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 05 00 Common Work Results for Integrated Automation*.

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.

2.5 PROGRAMMABLE DEVICES FOR ELECTRICAL METERING

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

B. Programmable controllers shall be a member of the Modbus Organization and use Modbus TCP. Controllers shall support polling and updating registers and expansion for hardwired meters.

C. Any energy management system hardware installed on any Owner site shall not be limitedin their ability to communicate with a specific brand or model.

2.6 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 setup on the BAS 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.

2.1 CONTROLS ENCLOSURES:

A. All new controllers shall be installed inside an enclosure. All enclosures larger than 12” X 12” shall have a locking hinged door.

B. All control enclosures shall come with a local, internal 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 4. Stainless steel, poly, or fiberglass shall be suitable material for outdoor enclosures in high humidity areas.

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.

1. Breaker panel and circuit number of power sources shall also be labeled inside panel door.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. If an existing field controller is unable to be integrated into the BAS 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 05 00 Common Work Results for Integrated Automation*.

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 BAS 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.

END OF SECTION

SECTION 25 15 00 – INTEGRATED AUTOMATION SOFTWARE

PART 1 - GENERAL

1.1 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 01 00 Operation and Maintenance of Integrated Automation*
3. *25 05 00 Common Work Results for Integrated Automation*
4. *25 06 00 Schedules for Integrated Automation*
5. *25 08 00 Commissioning of Integrated Automation*
6. *25 11 00 Integrated Automation Network Devices*
7. *25 14 00 Integrated Automation Local Control Units*
8. *25 35 00 Integrated Automated Instrumentation and Terminal Devices for HVAC*
9. *25 36 00 Integrated Automation Instrumentation and Terminal Devices for Electrical Systems*

1.2 REFERENCES

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

1.3 ACRONYMS

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

1.4 DEFINITIONS

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

1.5 SYSTEM DESCRIPTION

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

1.6 SUBMITTALS

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

1.7 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

B. Software shall be developed and maintained by a manufacturer with a minimum of 10 years of experience in operational technology systems.

1.8 WARRANTY

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

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

1. The Owner 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 installed on-site shall not be licensed for expiration where the software shall cease to function fully as when license is not expired.

2.2 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

3.1 NETWORK COMMUNICATION REQUIREMENTS

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

3.2 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 05 00 Common Work Results of Integrated Automation*
2. *25 10 00 Network Equipment*

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 be required to run on the server shall be pre-approved by The Owner, and proper access shall need to be granted to the approved Controls Contractor to set up these services.

3.3 ENTERPRISE OPERATIONAL TECHNOLOGY SOFTWARE

A. Software must be installed by a Controls Contractor with server and product experience.

B. 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*

C. Any additional software required for configuration or maintenance must also be installed on the same server(s) as the enterprise operational technology software.

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

E. Any access to the internet for updates, or access for remote support, external to the Controls Contractor approved for the project is prohibited.

F. The Owner shall have an administrator account created in any installed enterprise operational technology

software priorto project close-out, and all generic and default accounts shall be deactivated or removed.

3.4 DEVICE CONFIGURATION/PROGRAMMING SOFTWARE

A. Any software required for installed field device programming, configuration, or maintenance shall be installed on The Owner's server as part of the project.

B. If an older version of software is installed and the newer version shall have an adverse effect with existing device connections, both software shall need to be installed in parallel ifexisting devices cannot be upgraded as part of project.

C. If parallel versions of software are installed, documented step-by-step on switching betweenand using both software must be presented to The Owner at close-out and demonstrated in training session.

3.5 INTEGRATION

A. System integration shall be completed by the OT Contractor.

B. At a minimum, the BAS shall be able to communicate through data lines, with existing building automation system for monitoring and control.

C. Trend data shall be discovered into the server as BACnet trend objects and shall be imported upon the trend sample capacity in the field controller exceeding 70% of the total samples for the trend.

1. New trend objects may be generated for BACnet objects not currently trended at The Owner's discretion.

D. Alarms shall be discovered into the server 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 server level 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, The Owner shall be notified for approval of logic recreation.

3.2 SCHEDULES FOR BUILDING AUTOMATION

A. Scheduling as defined in this section shall be completed by the Controls 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 inthe device.

3.3 TRENDING FOR OPERATIONAL TECHNOLOGY

A. Trending as defined in this section shall be completed by the Controls Contractor as defined in section *25 00 00 Integrated Automation*.

B. Trend setup and discovery into the server shall be completed by the Controls Contractor and is referenced in section *25 15 00 Integrated Automation Software*.

C. Building Automation System:

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

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

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

data.

4. Devices with trending capabilities shall be setup to export trends as BACnet objects directly to the server.
5. 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.
6. Minimum trending shall be set up as follows:
    a. Hardwired and calculated (e.g. calculated supply air temp reset setpoint) analog objects and shall be trended at 15-minute intervals.
    b. Hardwired Boolean objects shall be trended as COV.
    c. Virtual Boolean and enumerated objects that indicate status, command, mode, etc. shall be trended as COV.
    d. Writable manual setpoints (e.g. occupied room temp setpoint) shall be trended as COV.

3.4 NOTIFICATIONS AND ALARMING

A. Notifications and alarms as defined in this section shall be completed by the Controls Contractor as defined in section *25 00 00 Integrated Automation*.

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

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

D. Building Automation System Alarms
    1. Minimum notification parameters shall be the following:
        a. 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.
        b. 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.
        c. 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.
        d. Normal, Level 4 – Alarms under this notification class shall show up on a GUI alarming console.
    2. 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:
        a. Level 1: Latching
        b. Level 2: Latching
        c. Level 3: Non-Latching
        d. Level 4: Non-Latching
    3. Operators with the appropriate security clearance shall have the ability to put any deviceinto and out of Maintenance Mode.
        a. While in Maintenance Mode, all alarms associated with the device will be suppressed, except for Life Safety alarms.
        b. 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 stillin Maintenance Mode.

c. See section *25 15 00 Integrated Automated Software* for security clearances for user.

4. 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:

   a. Level 1: 1 second

   b. Level 2: 10 seconds

   c. Level 3: 1 minute

   d. Level 4: 5 minutes

E. 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.

F. 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.

G. Communication alarming shall be setup to notify The Owner of any communication failure or data lapse potential. These instances can include:

   1. Loss of network communication of any device

   2. Stale or unchanged data, especially in Modbus registers

3.6 GENERAL GRAPHICS

A. New graphics a shall be created in existing system or newly installed system, as directed by The Owner.

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

C. Graphical representations for newly installed control devices shall be schematically accurate and reflect the physical layout of the equipment.

D. Graphical displays shall be visible via web browser and shall not require additional applications or applets to function properly.

E. Graphical displays shall automatically resize for the user based on their screen size.

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

G. Graphics shall be accessible through single-sign-on (SSO) functionality with different access rights and landing pages. Refer to Section 25 05 00 1.11 Security Requirements for additional details. Groups shall also be established to assign usernames with different access rights. A minimum of four groups will be established with the minimum access listed below:

   1. Read Only access to graphics and trends.

   2. Building Manager – Ability to override space temperatures, view alarms, view, and setup trends, and set schedules.

   3. Operator – Building manager access plus the ability setup and acknowledge alarms, and to override all points.

   4. Administrator – Full access.

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

   1. Administrator users shall be the only users with the ability to override an object into the emergency priority level.

2. All overrides shall have a maximum override time of 24 hours, which shall be adjustable by an Administrator level user. Administrator level users shall be allowed to permanently override a writable object.

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

1. Numeric Objects shall allow you to enter the override value and release the object from the override state.
2. Binary and Enumerated Objects shall allow you select an override value from a dropdown list and release the object from the override state.
3. A dialog box shall be opened upon override of an object for the user to input an override explanation.
4. 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.

J. All overridden values shall be clearly displayed on the graphical screens with a different color and on an override summary table that shall be available on the landing page of the graphical user interface.

K. Values and symbols representing equipment shall be able to change color or become animated based on status.

1. 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.
2. Binary objects shall show up as Green when their values are “Normal” and Red when their values are “Alarm”.
3. Objects with associated alarms shall change their background color to red when the object is in alarm.

L. Objects shall change their background color to purple when the object is overridden.

3.7 GENERAL GRAPHICAL REQUIREMENTS FOR EQUIPMENT AND SYSTEM SCHEMATICS

A. Schematics shall be 2-D or isometric and shall be based substantially on the schematics provided on Drawings.

B. 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:

1. Temperature values shall be set to one decimal place.
2. Percentage values shall be set to zero decimal places.
3. Building pressure in in/WC shall be set to three decimal places.
4. Static pressure in in/WC shall be set to two decimal places.
5. Pressure in psi shall be a minimum of one decimal place, depending on application.
6. Electrical Voltage values in Volts shall be set to one decimal place.
7. Energy values in BTU shall be set to three significant figures.
8. Flow values in GPM shall be set to one decimal place.
9. Electrical current values in Amps shall be set to zero decimal places.
10. Gas Volume values in Cubic Feet shall be one decimal places and Gas Volume in Cubic Feet per Hour shall be set to zero decimal places.
11. Energy power values in kW shall be set to one decimal places and in kWh shall be zero decimal places.

C. 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.

D. Animation or equipment graphic color changes shall be used to indicate on/off status of mechanical or electrical components.

E. 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.

F. Displays shall show all points relevant to the operation of the system, including setpoints.

G. The current value and point name of every I/O point and setpoint shall be shown on at least one graphic and in its appropriate physical location relative to building and mechanical and electrical systems.

H. Show weather conditions, such as local building outside air temperature and humidity, in the upper right-hand corner of every graphic.

I. The contract document drawings will be made available to the Contractor in AutoCADformat upon request for use in developing floor plans. However, The Owner does not guarantee the suitability of these drawings for the Contractor's purpose.

J. For all equipment 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.

K. For all equipment 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.

L. For all controlled points used in control loops, show the setpoint adjacent to the current value of the controlled point.

3.8 MINIMUM REQUIREMENTS FOR INDIVIDUAL BAS GRAPHICS

A. Navigation Tree:

1. 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 (e.g. Air Handlers)
   c. Subsystem or Equipment Name

B. Site homepage:

1. Background shall be a campus map, approximately to scale. Include links to each building, central plant, etc.
2. Site homepage shall have a visible alarm console showing a consolidated view of all alarms across all buildings on the site.
3. 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.

C. Building homepage:

1. 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.
2. Building homepage shall also have a visible alarm console showing all alarms relevant to the building.
3. Building homepage shall have an override summary that will show the user the currentlist of overridden objects and their associated equipment within the building.

D. Floorplans:

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

2. 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.
3. 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. Summary Pages

1. Provide summary graphics that show key variables listed in columns for similar equipment. Each equipment noted in the summary pages will have a direct hyperlink to their respective MEP graphic.
2. All values noted below may not be applicable in all buildings.
3. Air Handling Unit Summary:
    a. Equipment name
    b. Zone served
    c. Operating mode
    d. On/off status
    e. Supply air temperature
    f. Supply air temperature setpoint
    g. Fan command/speed/status (or amps where applicable)
    h. Duct static pressure
    i. Duct static pressure setpoint
    j. Outdoor air and return air damper position
    k. Coil valve command and/or positions
4. Fan Coil Unit Summary:
    a. Equipment name
    b. Zone served
    c. Operating mode
    d. On/off status
    e. Zone temperature
    f. Zone temperature setpoint
    g. Supply air temperature
    h. Supply air temperature setpoint
    i. Fan command/speed/status
    j. Coil valve command and/or positions
5. Relief Air Damper Summary:
    a. Damper number
    b. Relief damper enable/disable

c. Building pressure
d. Damper command
e. Damper feedback

END OF SECTION

SECTION 25 35 00 – INTEGRATED AUTOMATION INSTRUMENTATION AND TERMINAL DEVICES FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines requirements for integrated automation instrumentation and terminal devices for HVAC. Associated hardware shall be defined herein as sensors (e.g. temperature probe), and control devices (e.g. actuators).

B. Related Sections:

1. *25 00 00 Integrated Automation*
2. *25 01 00 Operation and Maintenance of Integrated Automation*
3. *25 05 00 Common Work Results for Integrated Automation*
4. *25 06 00 Schedules for Integrated Automation*
5. *25 08 00 Commissioning of Integrated Automation*
6. *25 11 00 Integrated Automation Network Devices*
7. *25 14 00 Integrated Automation Local Control Units*
8. *25 15 00 Integrated Automation Software*
9. *25 36 00 Integrated Automation Instrumentation and Terminal Devices for Electrical Systems*

1.2 REFERENCES

A. Refer to *25 00 00 Integrated Automation and 25 08 00 Commissioning of Integrated Automation*.

1.3 DEFINITIONS

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

1.4 SYSTEM DESCRIPTION

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

1.5 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 CONTROLLERS

A. Refer to *25 11 00 Integrated Automation Network Devices* and *25 14 00 Integrated Automation Field Devices*.

2.2 ELECTRICAL WIRING AND DEVICES

A. All electrical work shall comply with Division 26 requirements and all building electrical codes.

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 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 recommended by the devicemanufacturer.

2.3 CONTROL VALVES

A. Acceptable Manufacturers:

1. Belimo
2. Siemens
3. Bray (Butterfly valves only)
4. Or Will County Approved 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 4 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.

2.4 ACTUATORS

A. Acceptable Manufacturers:

1. Belimo
2. Siemens
3. Or Will County Approved 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 thatactuators 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 or 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 as 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 the 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 aV- 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 of 5 inch-pounds per square foot of damper.

c. Terminal unit dampers shall be a minimum of 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 a 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 areacceptable, and normal position refers to the position with zero control signal.

Table 1

Normal Positions and Fail-Safe Requirements for Actuators

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	No – Fail in place
AHU Cooling Coil Valve	Closed	
FCU Cooling Coil Valve	Open	
Isolation Valve	Open	
VAV Box Damper	Open	

2.5 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. ACI
   b. BAPI
   c. Or Will County Approved 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 ofcondensation. See section 2.7 for additional humidity sensor requirements.

C. Immersion Temperature Sensors
1. Acceptable Manufacturers:
    a. ACI
    b. BAPI
    c. Or Will County Approved 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 diameteror eight (8) inches.

D. Room Temperature Sensors
1. Acceptable Manufacturers:
    a. BAPI
    b. ACI
    c. Or Will County Approved Equal
2. For controller makes and models that are capable of utilizing a subnetworked communicating room sensor 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 BAS 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:
        a) Display room temperature, room temperature setpoint, and occupancy mode.
        b) Allow for push button occupancy override. Override time shall be adjustable at the GUI.
        c) CO2 and occupancy sensing shall be required for systems utilizing Demand Control Ventilation (DCV).
        d) For rooms utilizing multiple sensors, only one of the room sensors shall allow for room temperature setpoint adjustment.
    b. Common Areas:

a) Display room temperature only.

b) 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 ofcondensation. See section 2.7 for additional humidity sensor requirements.

E. Outside Air Sensors

1. Acceptable Manufacturers:

a. BAPI

b. Vaisala

c. MAMAC

d. Or Will County Approved 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.

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

2.6 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. BAPI

b. ACI

c. Vaisala

d. Or Will County Approved 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 95%RH.

4. Sensor enclosures shall be gasketed to prevent air leakage and vibration noise.

2.7 DIFFERENTIAL PRESSURE TRANSMITTERS - AIR

A. Acceptable Manufacturers:

1. Setra
2. Dwyer
3. BAPI
4. ACI
5. Or Will County Approved 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.

2.8 AIRFLOW SENSING – VAV BOX VELOCITY PRESSURE TRANSDUCERS

A. Acceptable Manufacturers:

1. Field Controller Manufacturer (see 25 14 00)
2. Or Will County Approved 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.

2.9 AIRFLOW SENSING – INDUCTION BOX THERMAL DISPERSION

A. Acceptable Manufacturers:

1. Ebtron
2. Onicon
3. Or Will County Approved 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.

2.10 CROSS AIRFLOW AVERAGING SENSOR (FOR VAV AIRFLOW)

A. Acceptable Manufacturers:

1. Titus
2. Krueger
3. Or Will County Approved Equal

B. 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.

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

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

2.11 FREEZE PROTECTION

A. Acceptable Manufacturers:

1. Siemens
2. Johnson Controls
3. ACI
4. Or Will County Approved Equal

B. Freezestats shall be provided on all air handling units that utilize fresh air makeup.

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 BAS.

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.

2.12 CURRENT SWITCHES

A. Acceptable Manufacturers:

1. Functional Devices
2. ACI
3. Or Will County Approved Equal

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

2.13 CONTROL RELAYS

A. Acceptable Manufacturers:

1. Functional Devices
2. IDEC
3. ACI
4. Or Will County Approved 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 control 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.

2.14 CONTROL TRANSFORMERS AND POWER SUPPLIES

A. Acceptable Manufacturers:

1. Functional Devices
2. IDEC
3. Or Will County Approved Equal

B. Transformers shall be UL listed, Class 2 current limiting type. If current limiting isunavailable, provide resettable 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 limitedto 80% of rated capacity.

D. Transformers shall be mounted external of the control enclosure with no 120V in control box unless UL listed as an assembly.

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

3.1 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 installationwork shall perform, at their expense, necessary changes in specified work caused by failure or neglect to report discrepancies.

3.2 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 Subcontractor.

B. The Contractor performing the installation work shall be responsible for work andequipment 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.

3.3 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, theContractor performing the installation work shall correct conditions without extra charge.

C. Test and Balance:

1. Provide the Test and Balance Contractor with a single set of necessary tools to interface to control system to perform testing and balancing.
2. The Controls Contractor shall train the Test and Balance Contractor to use control system interface tools.
3. The Controls 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.

3.4 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. Where conduit is subject to significant physical damage, such as areas with heavy equipment traffic, galvanized rigid conduit (GRC) shall be implemented.

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: 0° F to 120° F, 0% RH to 90% RH noncondensing.
2. Conditioned Spaces: 32° F to 104° F, % RH to 90% RH noncondensing.

3.5 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.

3.6 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, neatly compiled, and delivered to The Owner with a transmittal document.

C. Unless otherwise directed, the Contractor responsible for installation work is not responsible for repair or replacement of existing equipment and systems, valves, dampers, or actuators. Notify Engineer or The Owner, as required by the project, in writing immediately of existing equipment that requires maintenance.

D. Deliver the following to The Owner if the 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
6. Existing meters

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

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

G. 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.

H. Patch holes and finish to match existing walls.

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

3.7 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 wiring shall be UL listed for its respective application.

E. Install wiring in raceway where wire may be subject to mechanical damage and at levels below 10 feet, Division 26 to supersede this requirement, in mechanical, electrical, or service rooms and above hard ceilings or over large pieces of equipment. Underground rated cable shall not be used in above grade applications.

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 in the control panel. Control wiring will be connected using terminal blocks.

J. Wire nuts shall be allowable for terminal and instrumentation device applications.

K. 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.

L. 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.

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

N. 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.

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

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

Q. Use color-coded conductors throughout.

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

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

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

U. 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.

V. 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 enclosures with fittings per Division 26 requirements.

3.8 COMMUNICATION WIRING

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

B. Existing serial communication wiring shall not be reused. Category 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 lengthis commercially available. Splices in communication wiring are not permitted.

G. BACnet MS/TP communications wiring will be installed in accordance with ASHRAE/ANSI Standard 135-2024. 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 100pF 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.

3.9 INSTALLATION OF SENSORS

A. Install sensors according to manufacturer's recommendations. No sensor shall be used as a junction box. This allows removal of individual devices for replacement as necessary.

B. Mount sensors rigidly and adequately for operating environment.

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

D. Care shall be taken to ensure sensors maintain accuracy integrity throughout the project implementation. Where any project work carried out in concurrence with the integrated automation project results in the creation of significant amounts of particulate matter, including dust and VOCs, is occurring, it may be necessary for sensors to be installed after acceptable air quality has been restored.

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

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

G. 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.

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

I. Install outdoor air temperature and humidity sensors on north wall at designated location with sun shield.

J. 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 tothe 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.

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

water gauges.

L. 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 shall require manual reset accessible outside of the equipment. Provide contacts that allow DDC software to monitor safety switch status.

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

3.10 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.

3.11 IDENTIFICATION

A. Use printed labels to 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 indicating the equipment controlled and controller names. 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.

H. For equipment that is accessed through access panels or drop ceilings a printed label shall be placed on the external surface indicating the equipment ID in a color that contrasts with the surface it is affixed to.

3.12 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

SUBMITTAL DOCUMENTS

- Listing of project contact information
- Shop drawings as detailed in section 25 00 00, including the following:
  - Network Riser Diagram
  - Mechanical System Schematics
  - Sequence of Operations
  - Electrical Wiring Diagrams
  - Bill of Materials
  - Valve & Damper Schedules
  - System Graphics
- Product data as detailed in section 25 00 00, including the following:
  - Technical data sheets, installation guides, technical manuals & owner's manuals
  - BACnet PICS
  - BACnet BTL-listing certificate(s) for all devices
  - IT hardening guide for all IP-based devices and software products
  - Control system & application specific software information
  - Product/software capacity & functionality licensing information
- Completed Device Schedules, per section 25 06 00 (read/write electronic format)
- Completed Object Naming Submittal including the Object Name and description (read/write electronic format)
- Completed CMMS Inventory Submittal, per section 25 06 00
- Owner/operator training syllabus & tentative schedule, per sections 25 00 00 and 25 08 00
- Warranty information, per section 25 01 00

AS-BUILT DOCUMENTATION

- Listing of project contact information
- Updated design submittal including:
    - Shop drawings
    - Editable Sequence of Operations Files
    - Product data Submittal
    - Device Schedules, per section 25 06 00 (read/write electronic format)
    - Object Naming Submittal including the Object Name and description (read/write electronic format)
    - CMMS Inventory Submittal, per section 25 06 00
- Control System O&M Manual including:
    - Manufacturer product documentation (Product Data Submittal)
    - Full points list
    - Setpoints list
    - Schedules list
    - Programs list
    - Full record of all program logic
    - Programming Instructions
    - Point-to-point checkout documentation
    - Warranty Information