

# ALERTON

SECTION 15900 (23 09 00)

DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

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**\*\* NOTE TO SPECIFIER \*\*** Alerton; HVAC instrumentation and controls.

This section is based on the products of Alerton, which is located at:

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[Click Here](#) for additional information.

Since 1981, Alerton has helped pioneer smart building technology with its intuitive, powerful control tools that helped shape today's smart building management. Its innovative building management solutions optimize energy efficiency, operational simplicity and occupant comfort for thousands of buildings worldwide. With flexible architecture, open protocols and cutting-edge technology, Alerton is the leading solution for managing an entire building ecosystem.

Alerton partners with an exclusive, global network of independent Dealers and System Integrators who provide expert design, engineering, implementation, and ongoing support. The combination of large-scale global manufacturing and local, in-market partners provides building owners and occupants with the best possible experience. As part of Honeywell International Inc.'s Automation and Controls group, Alerton retains its entrepreneurial and pioneering spirit while gaining the additional financial and technological resources of a multi-national Fortune 100 corporation. Our business excellence starts with superb local dealer and factory support backed by the power of Honeywell.

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

**\*\* NOTE TO SPECIFIER \*\*** Delete items below not required for project.

A. Building Automation System (BAS), utilizing direct digital controls. (ASCENT)

### 1.2 RELATED WORK

A. Native BACnet-based system, with Microsoft Windows 10 compatible operator's workstation. Workstation, building controllers, application controllers, and input/output devices communicate using protocols and network standards per ANSI/ASHRAE Standard 135, BACnet. Workstations, controllers, and unitary controllers, to be native BACnet. Do not use gateways for controller communication. Gateways may be used to communicate with existing systems or systems installed under other sections.

1. BACnet-compliant hardware and software meeting system's functional specifications.

Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system.

2. Individual hardware layouts, interconnection drawings, and software configuration from project design data.
3. Implement detailed design for analog and binary objects, system databases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.
4. Design, provide, and install equipment cabinets, panels, data communication network cables needed, and associated hardware.
5. Interconnecting cables between supplied cabinets, application controllers, input/output devices, operator's terminals and peripheral devices (including but not limited to printers) supplied under this section.
6. Manufacturer's specifications for items supplied.
7. Specialists and technicians; assist installation, startup, and commissioning.
8. Operator and technician training program as described herein.
9. As-built documentation, operator's terminal software, diagrams, and associated project operational documentation (such as technical manuals) on approved media accurately representing the final system.
10. New sensors, dampers, valves, and new electronic actuators. No used components.
11. Owner will have full licensing and access rights for network management and operating workstation features for ongoing maintenance and operation of BMS.
12. BMS workstation will host graphic files for control system. Graphics and navigation schemes for project are to match any that are on existing site/campus.

### 1.3 RELATED SECTIONS

**\*\* NOTE TO SPECIFIER \*\* Delete any sections below not relevant to this project; add others as required.**

- A. Section 15050 (23 05 00) - Common Work Results for HVAC.
- B. Section 25 00 00 – Master System Integration
- C. Section 26 27 13 – Low Voltage Electric Metering
- D. Section 16050 (26 27 26) - Common Work Results for Electrical.

### 1.4 RELATED WORK SPECIFIED ELSEWHERE

**\*\* NOTE TO SPECIFIER \*\* Delete any subparagraphs below not relevant to this project; add others as required.**

- A. Products Supplied but Not Installed Under This Section:
  1. Control valves.
  2. Flow switches.
  3. Wells, sockets and inline hardware for water sensors (temperature, pressure, flow).
  4. Automatic control dampers, where not supplied with equipment.
  5. Airflow measuring stations.
  6. Terminal unit controllers and actuators, when installed by terminal unit manufacturer.
  7. Variable frequency drives. (Does not include VFDs integral to chillers or boilers).
- B. Products Installed but Not Supplied Under This Section: None.
- C. Products Not Furnished or Installed but Integrated with the Work of This Section:
  1. Chiller control systems.
  2. Boiler control systems.
  3. Pump control packages.
  4. In-line meters (gas, water, power).

5. Refrigerant monitors.
  6. Chemical water treatment.
  7. Smoke detectors (through alarm relay contacts).
- D. Work Required Under Other Divisions Related to This Section:
1. Power wiring to line side of motor starters, disconnects or variable frequency drives.
  2. Provision and wiring of smoke detectors and devices relating to fire alarm system.
  3. Campus LAN (Ethernet) connection adjacent to Operator Workstation.

## 1.5 REFERENCES

**\*\* NOTE TO SPECIFIER \*\* Delete references from the list below that are not actually required by the text of the edited section.**

- A. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
  1. ASHRAE 90.1-2016, "Energy Efficient Design of New Buildings"
  2. ASHRAE 62.1-2013, "Ventilation for Acceptable Indoor Air Quality"
  3. ASHRAE 189.1-2011, "Standard for the Design of High-Performance, Green Buildings"
  4. ASHRAE 135-2016 " BACnet®"
  5. ASHRAE 55-2013, "Thermal Environmental Conditions for Human Occupancy"
- B. American National Standards Institute (ANSI): ANSI/ASHRAE Standard 135, BACnet.
- C. Underwriters Laboratories:
  1. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
  2. UL 864 UUKL listing for Smoke Controls for any equipment used in smoke control sequences.
  3. UL 2043 Underwriters Laboratories Standard for installation in air handling spaces and plenums
- D. Electromagnetic Compatibility (EMC): EMC Directive 89/336/EEC (European CE Mark).
- E. The Federal Communications Commission (FCC): FCC Part 15, Subpart J, Class A.
- F. National Electrical Code (NEC).

## 1.6 SPECIFICATION NOMENCLATURE AND DEFINITIONS

- A. Acronyms Used in this Specification:
  1. ACM: Ascent Control Module.
  2. Actuator: Device that opens or closes valve or damper in response to control signal.
  3. AI: Analog Input.
  4. AO: Analog Output.
  5. Analog: Continuously variable state over stated range of values.
  6. BAS: Building Automation System.
  7. BMS: Building Management System
  8. Compass: Alerton Workstation Software.
  9. DDC: Direct Digital Control.
  10. FC: Fail closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
  11. FO: Fail open position of control device or actuator. Device moves to open position on loss of control signal or energy source.
  12. GUI: Graphical User Interface.
  13. HMI: Human Machine Interface.
  14. HVAC: Heating, Ventilating and Air Conditioning.

15. LAN: Local Area Network.
16. MSDB - Microsoft SQL Database
17. Modulating: Movement of control device through an range of values, proportional to an infinitely variable input value.
18. Motorized: Control device with actuator.
19. NC: Normally closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
20. NO: Normally open position of switch after control signal is removed; or the open position of a controlled valve or damper after the control signal is removed; or the usual position of a manually operated valve.
21. Operator Workstation: PC running Compass software and any required software tools applicable for day to day operation of the BMS.
22. P: Proportional control; control mode with continuous linear relationship between observed input signal and final controlled output element.
23. PI: Proportional-Integral control, control mode with continuous proportional output plus additional change in output based on both amount and duration of change in controller variable (reset control).
24. PICS: BACnet Product Interoperability Compliance Statement.
25. PID: Proportional-Integral-Derivative control, control mode with continuous correction of final controller output element versus input signal based on proportional error, its time history (reset) and rate at which it's changing (derivative).
26. Point: Analog or discrete instrument with addressable database value.
27. VLC: VisuaLogic® Controller.
28. WAN: Wide Area Network.

## 1.7 SUBMITTALS

- A. Submit under provisions of Section 01300.
- B. Product Data: Construction details, layout, and location of control panels within building, including instrument location in panels and labelling. Indicate mechanical equipment associated with each controller and area in building being served by that equipment. For terminal unit control, a room schedule listing mechanical equipment tag, room number of space served, address of DDC controller, and pertinent information required for service.
  1. Manufacturer's data sheets on each product to be used.
  2. Preparation instructions and recommendations.
  3. Storage and handling requirements and recommendations.
  4. Typical installation methods.
- C. Shop Drawings: Material details, construction, finish and adjacent construction relationship.
  1. Engineering drawings, control sequence, and bill of materials for approval.
  2. Standard Sizes for Drawings: 11 inches x 17 inches (ANSI B).
  3. Eight complete physical sets of submittal drawings, and approved electronic media.
- D. System Documentation: Include the following in submittal package.
  1. System Configuration Diagrams: Simplified block format. Note software addressing for device communications for devices. Indicate locations of ethernet switches.
  2. Input/output object listings and an alarm point summary listing.
  3. Electrical drawings showing system internal and external connection points, terminal block layouts, and terminal identification.
  4. Bill of materials, valve schedule, and damper schedule.
  5. Instructions and drawings, for installation, operation, maintenance, preventive maintenance, troubleshooting, and spare parts for list control devices.

6. BACnet Protocol Implementation Conformance Statements (PICS) per ASHRAE Standard 135: For system elements-Operator's Workstations, building controllers, application controllers, routers, and repeaters.
  7. Description and documentation of proprietary (non-BACnet) services and/or objects.
- E. Project Management: Detailed project design and installation schedule with time markings and details for hardware items and software development phases.
1. Target dates for transmission of project information and documents. Indicate timing and dates for system installation, debugging, and commissioning.
  2. Supply products to affected trades in time to prevent interruption of construction.
  3. Maintain integrity of shipping cartons for each piece of equipment and control device through shipping, storage and handling as required to prevent equipment damage.

## 1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified. Five years documented experience.
1. BAS System: Designed, installed, commissioned, and serviced by manufacturer authorized and trained personnel. Support facility within 2 hours response time of site with technical staff, spare parts, and test and diagnostic equipment.
  2. Contractor: Full-time, on-site, experienced project manager responsible for supervision of design, installation, start-up and commissioning of BAS.
  3. Materials and Equipment: Latest standard design complying with requirements.
  4. UL Listed under Standard UL 916, category PAZX: BAS peer-to-peer network controllers, central system controllers and local user displays.
  5. Electronic Equipment: Conform to requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
  6. Control System: Engineered, programmed and supported by representative's local office/ No less than four hour response, 24 hours a day, 7 days a week.
- B. Installer Qualifications: Two years documented experience with projects of similar scope and complexity.
- C. Source Limitations: Each product type to be from a single manufacturing source.

**\*\* NOTE TO SPECIFIER \*\*** Include mock-up if the project size or quality warrant the expense. The following is one example of how a mock-up on might be specified. When deciding on the extent of the mock-up, consider all the major different types of work on the project.

- D. Mock-Up: Construct with actual materials for Architect's review and to not delay construction progress. Locate as acceptable to Architect providing temporary foundations and support.
1. Intent of mock-up is to demonstrate quality of workmanship and visual appearance.
  2. If mock-up is not acceptable, rebuild mock-up until satisfactory results are achieved.
  3. Retain mock-up during construction as standard for comparison with completed work.
  4. Do not alter or remove mock-up until work is completed or removal is authorized.

## 1.9 PRE-INSTALLATION CONFERENCE

- A. Convene approximately two weeks before scheduled Work commencement. Attendees to include Architect, Contractor and trades involved. Agenda: Include schedule, responsibilities, critical path items and approvals.

## 1.10 DELIVERY, STORAGE, AND HANDLING

- A. Store and handle in strict compliance with manufacturer's written instructions and recommendations.
- B. Protect from damage due to weather, excessive temperature, and construction operations.

## 1.11 PROJECT CONDITIONS

- A. Maintain environmental conditions within limits recommended by manufacturer for optimum

results. Do not install products in environmental conditions outside recommended limits.

1. If ambient conditions are not met at time of delivery, manufacturer reserves the right to void the warranty.

## 1.12 WARRANTY

- A. Manufacturer's Warranty: Limited warranty against defects in materials and workmanship. Covers costs for parts, labor, associated travel, and expenses for a period of one year from completion of system acceptance and applies equally to hardware and software.
  1. Personnel supporting the hardware and software warranty agreement will provide on- or off-site service in a timely manner after failure notification. Acceptable Response Time: Within 24 hours, Monday through Friday; 48 hours on Saturday and Sunday.

## PART 2 PRODUCTS

### 2.1 MANUFACTURERS

- A. Acceptable Manufacturer: Alerton; 715 Peachtree Street NE – Atlanta,30308. ASD. Phone: 425-921-4900. Fax: 425-921-4872. Email: web.inquiries@alerton.com Web Site: www.alerton.com.

**\*\* NOTE TO SPECIFIER \*\* Delete one of the following two paragraphs; coordinate with requirements of Division 1 section on product options and substitutions.**

- B. Substitutions: Not permitted.
- C. Requests for substitutions will be considered in accordance with provisions of Section 01600.

### 2.2 SYSTEM DESCRIPTION

- A. Except as indicated, system supplier to secure and pay for all permits, inspections, and certifications required for his work, and arrange for necessary approvals by the governing authorities.
- B. BAS: Network of interoperable, stand-alone building controllers, field controllers on logical networks, graphics and programming for complete system.
  1. Password access to features, functions and data contained in BAS.
  2. Software for complete operating system, as specified, as integral part of supervisory controller. Not dependent upon higher level computer for execution.
  3. System Backup: Electronic copies of software, project graphics, setpoints, and system parameters. Backups will allow Owner to restore system if necessary.
- C. Distributed Logic Control System: Software and hardware per ANSI/ASHRAE Standard 135.
  1. System controls mechanical equipment, including unitary equipment such as VAV boxes, heat pumps, fan-coils, AC units, air handlers, boilers, chillers, and listed equipment using native BACnet-compliant components.

**\*\* NOTE TO SPECIFIER \*\* Add irrigation, lighting control, any other monitoring in this paragraph, to make sure it is included in project bids and delivered by contractors.**

2. Operator's Workstation Software: **BAS/BMS** application written utilizing BACnet protocols. Software functions to include password protection, scheduling, alarming, logging of historical data, full graphics including animation, after-hours billing, demand limiting, and full suite of field engineering tools including graphical programming applications.
  - a. Programming to make future changes to e system, controllers, field level devices, system changes, scheduling, and trending.
  - b. Field engineering tools, graphical programming, graphical displays, and applications.
3. Building Controllers: Building management software, with scheduling building control strategies and optimum start and logging.

- a. Energy Management Software/Firmware: Resident in field hardware.
  - b. Operator's Terminal Software: Used to access field-based building management functions. Zone-by-zone direct digital logic control of space temperature, scheduling, runtime accumulation, equipment alarm reporting, and override timers for after-hours usage.
4. Room Sensors: Viewable digital readout of room temperature, and outside air. Adjustable room setpoint within preset limits and set desired override time. Start and stop unit from digital sensor. Include wiring and firmware for field service mode allowing technicians to balance VAV zones and access parameters in zone controller directly from room sensor. Field service mode must have ability to be locked out.

**\*\* NOTE TO SPECIFIER \*\*** If digital readout not desired, replace (4) with the following: Room sensors shall be architecturally pleasing, sense temperature, allow tenant to override system and adjust temperature setpoint. Include wiring for sensor and field service tool.

- 5. Application Controllers: Terminal units including VAV, HP and UV, air handler, central plant equipment, and other controlled equipment to be programmable. Mount next to controlled equipment. Communicate with building controller through BACnet LAN.

### 2.3 ADVANCED OPERATOR WORKSTATION – AOWS (COMPASS)

- A. Structure of Workstation Interaction: Server/Client relationship. Embedded web server for client browser access. Server to archive and store system data. Virtualized server environment. Web clients may access archive server data.
  - 1. Single server license shall provide the ability to read/write, log, alarm, schedule and graphically display all physical and virtual points in a device – be it a BACnet Building Controller (B-BC), Advanced Application Controller (B-AAC), Application Specific Controller (B-ASC), BACnet Gateway, or any other BACnet device.
  - 2. Device licensing that limits the number of points accessible in a device, as described above in paragraph 2.3.A.1 shall not be accepted and will not be approved as an alternate.
  - 3. Licensing based on number of users or seats shall not be accepted and will not be approved as an alternate.
  - 4. Single server license shall be provided for the following maximum connected devices.

**\*\* NOTE TO SPECIFIER \*\*** Delete options for maximum devices to be connected not required.

- a. Maximum Devices to be Connected: 10.
  - b. Maximum Devices to be Connected: 25.
  - c. Maximum Devices to be Connected: 50.
  - d. Maximum Devices to be Connected: 150.
  - e. Maximum Devices to be Connected: 450.
  - f. Maximum Devices to be Connected: 1000.
  - g. Maximum Devices to be Connected: 3000.
  - h. Maximum Devices to be Connected: As indicated on Drawings.
  - i. Not restrict system size based on point count (BACnet or Integration).
- B. Operator Workstation: General purpose, commercially available, computer.
    - 1. Operating System: 64-bit – Windows 10/Server 2016/Server 2019
    - 2. Processor: 2.5 GHz (or better), multi-core as required based on system size
    - 3. Memory: 8 GB RAM (or higher) as required based on system size
    - 4. Hard Drive: Minimum of 1 TB
    - 5. Network Interface Card: 10/100/1000 Mbs.

**\*\* NOTE TO SPECIFIER \*\*** Review regularly, add processing power as required for specific job.

- C. Sufficient storage to accommodate fully configured point databases, application databases,

- graphics files, user-defined reports, and historical data archived as specified.
- D. Graphic Based Displays: For each system.
    - 1. Operator Workstation: Point data for each system. Update every 30 seconds.
    - 2. Dynamically update data **from** any action by user.
    - 3. Graphic Displays: Iconic graphic representations of mechanical equipment. Display graphic files, text, trendlog, and dynamic object data displays including animation.
    - 4. Graphic Displays: "Drill Down" capability from main display to more specific system displays or navigation tree for building equipment and system diagnostic centric display organization.
      - a. Tree Navigation Contents: Customizable per-user and per-user-group basis.
    - 5. Systems with Terminal Unit Controls: Building floor plan with dynamic temperatures, drillable for more specific terminal information.
    - 6. Points on graphics allow user to change field-resident Operator Workstation functions associated with project, including setpoints, weekly and exception schedules, from any screen, whether screen shows text or graphic display. Do without reference to object addresses or other numeric/mnemonic indications.
    - 7. Protect display views unless operator credentials have proper access level. Assign access levels to each display/system object. Menu labels not to appear on graphic if operator does not have appropriate security level.
    - 8. Analog objects: Displayed with operator modifiable units. Input objects may be displayed as graphic items on display screen as an overlay to the system graphic.
    - 9. Information: Labeled with descriptors and shown with appropriate engineering units.
    - 10. DDCs system must provide graphic displays and files. Systems requiring graphics development or logic programming are prohibited. Graphic Files: JPG, GIF or PNG.
    - 11. Submit graphic displays to Owner for review and approval. Approved graphics to be in place prior to commissioning.
    - 12. Operator Workstation: Supply graphics library, to use unaltered or modified. Include library to assemble custom graphics. System to allow creation of new graphics.
    - 13. Data Displays: Ability to link to content outside of BAS system. Content to include, but not limited to launching external files in their native applications.
  - E. OmniGraphics: Graphics with custom geometry offering color gradient shading and variable opacity in scale to system variables; analog and **binary**, and color range settings.
    - 1. OmniGraphics Must Support:
      - a. Displaying current values in the geometric shapes.
      - b. Geometric shapes to be clickable allowing navigation to another graphic display.
      - c. Color Scale: Support using AVs and BVs to define the color scale ranges.
  - F. The Operator Interface: Support the following functions.
    - 1. Mouse-over tooltip information of graphic items or data points; can be turned off.
    - 2. Right mouse click access to context menu selection to create, view, or edit system functionality such as Schedule, Trendlogs, Alarms, Object Properties, and User Activity associated with display object selected.
    - 3. Automatic zooming to screen size to maximize display to display area. Can be enabled or disabled. Background color, flood fills remaining screen background.
    - 4. Support user configurable embedded Data Viewer for a persistent trend log data view to accompany system data and graphic information on a single display.
  - G. Password Protection: Preventing unauthorized use unless operator is logged on.
    - 1. Limits operator to assigned functions when logged on. Includes displays as outlined.
    - 2. Users: Individual User IDs, User Names, and Passwords. Case sensitive

alphanumeric character entry except for User ID. User ID, User Name, and Password will enforce minimum of 8 characters and stored in encrypted format.

3. Each user to be allowed individual assignment of control functions, menu items, navigation tree, and user-specific system start display, and restricted access to discrete BACnet devices to which user requires access.
  4. Passwords, user names, and access assignments: Adjustable via Compass. Password adjustable via web client.
  5. Users to have set access levels, which define access to displays and individual objects user may control. System to have 10 distinct access levels for assignment.
  6. Operator Workstation and Web Client: Auto logout feature when no keyboard or mouse activity is detected for time period, adjustable by system administrator. Enabled and disabled by system administrator. Screen message notifying log out.
  7. Permit effective date range, and effective time of day, User are permitted access.
  8. Active Directory Integration using LDAP for remote User Access control shall support to enforce minimum password length and enforce combination of the following requirements -
    - a. Upper Case letters
    - b. Lower Case letters
    - c. Base 10 digits (0-9)
    - d. Non-alphanumeric characters
    - e. Password expiration
    - f. User lockout after “x” failed attempts, where “x” is adjustable by the administrator
- H. Operator Activity Log: Tracks operator changes and activities.
1. Included in Operator Workstation. A log of what changed, who made the change, date and time of system activity, and value of change before and after. Operator may display activity, sort changes by user or operation and print Operator Activity Log.
  2. Activity log to be gathered and archived to MSDB as needed. Log to be able to exportable for spreadsheet display and sorting.
  3. User option to record commenting in Operator Activity Log upon system point change.
  4. Accessible via Web Client for viewing, sorting, filtering, and printing. Including via right mouse click and selection from context menu.
- I. Standard Scheduling:
1. Information to be in easy-to-read daily format including calendar of this month and next. Schedules to show actual ON/OFF times for day based on scheduling priority. Priority for Scheduling: Events, holidays and daily, with events being the highest.
  2. Holiday and Special Event Schedules: Display data in calendar format. Be able to schedule holidays and special events directly from these calendars.
  3. Operator to be able to change information for a given weekly or exception schedule if logged on with appropriate access privileges.
  4. Schedule Wizard for schedules set up. Walks user through schedule generation. Have its own pull-down selection for startup or may be started by right-clicking on value displayed on graphic and then selecting Schedule.
  5. Scheduling: Include optimum start based on outside air temperature, current heating/cooling setpoints, indoor temperature and previous starts history. Individual zones to have optimum start time calculated based on parameters listed. Operators to input schedules to set time that occupied setpoint is to be attained. Optimum start feature must calculate the startup time needed to match zone temperature to setpoint. Operators to be able to set a limit for maximum startup time allowed.
  6. List show currently defined schedules. Includes standard, holiday and event

schedules. User to be able to select a list showing scheduled points and zones.

7. Display of schedules must show ON times for standard, holiday and event schedules in different colors on a given day. OFF times must also be shown in additional colors. Operators may select from a calendar what days are to be scheduled and show points and zones affected. Operators may set time for one day and then match it to days of the week to be affected as a recurrence of same schedule.
  8. Any displayed data that is changeable by operator may be selected using the right mouse button and schedule selectable on screen. Selection of schedule using this method allows viewing of assigned schedule and allows the point to be scheduled.
  9. Schedule Support Functions: Drag-n-drop events and holidays on schedule calendar.
    - a. Drag-n-drop events default to two-hour period; can operator adjusted.
    - b. Drag-n-drop holidays default for OFF all day; edit for multiple-day holidays.
    - c. View affected zones when adding or editing timed events of a schedule.
  10. Web Client: A search list of scheduled points and zones to access schedule calendar.
  11. Schedule Time Blocks: Present schedule detail via mouse-over information.
- J. Advanced Scheduling:
1. Hierarchy of schedulable resources shall be customized to meet owner/operator specific scheduling needs and requirements.
  2. Schedulable resources shall support analog and binary data points, e.g. AV, AO, BV, BO objects.
  3. Each schedulable resource shall have its own unique schedule object.
  4. Holiday schedules shall support definition of a specific date or a perpetual holiday with a duration, for example the USA Thanksgiving two-day holiday.
  5. Calendar events set to be reoccurring events shall support the following recurrence patterns:
    - a. Repeat daily every x days or every weekday
    - b. Repeat weekly every x weeks on selected days of the week
    - c. Repeat monthly every x months on a specific date of the month or a specific day such third Saturday or last Monday.
    - d. Repeat yearly every x years on a specific month and date or a specified day of a specified month, e.g. last Wednesday of November
  6. Calendar events set to be reoccurring events shall support the following recurrence ranges: no end date, end after x occurrences, and end by a specified date.
  7. Calendar events set to be reoccurring events shall support a custom recurrence setting that is a collection of specified random dates that may have no logical pattern.
  8. Calendar events shall be configurable as a template that allows quick reuse and application by drag-and-drop onto any resource calendar. Any event shall be capable of being made into an event template.
  9. Calendar events shall require the following parameters: Event Name, Event Type (binary or setpoint), Start Date/Time, and End Date/Time.
    - a. Analog Event Type shall support selecting setpoint type to ensure that only compatible analog points are scheduled with a specified value
  10. Calendar Events shall support selection of schedulable resources by inheritance to all child resources or by selection of specific resources. Each selected resource shall support setting a start and end offset of +/- 6 hours from event start start/end times.
  11. The following conflict resolution rules shall be provided to determine what to do when schedulable resources have two events scheduled for the same time: Local vs. Inherited event; On vs. Off event; Newest vs. oldest event.
- K. Alarm Indication and Handling

1. AOWS shall provide visual, printed, and email means of alarm indication. Printout of alarms shall be sent to the assigned network printer. Alarm notification can be filtered based on the User ID's authorization level.
2. Alarm Manager shall provide log of alarm messages. History of alarm occurrences shall be archived to the data storage of the AOWS or a SQL data base. Each entry shall include a description of the event-initiating object generating the alarm. Description shall be an alarm message of at least 256 characters in length. Entry shall include time and date of alarm occurrence, time and date of object state return to normal, time and date of alarm acknowledgment, identification of operator acknowledging alarm, a comment from the operator who acknowledged the alarm, and the number of alarm occurrences.
3. Alarm Manager shall provide a means to filter all alarms that have been configured in the system for alarm description, current alarm state, default and customer date range, disabled/enabled, and priority level.
4. Alarm Manager shall provide a means to disable alarms for the purpose of performing maintenance without creating concern with unneeded alarm notifications.
5. Alarm messages shall be in user-definable text (English or other specified language) and shall be delivered either to the AOWS user interface or through remote communication using email (Authenticated SMTP supported).
6. Alarm Manager shall provide the permissioned ability to Clear alarm occurrences from the Alarm Manager table while retaining the alarm in the AOWS database for reporting purposes.
7. Alarm Manager shall provide the permissioned ability to Purge alarm occurrences from the both the Alarm Manager table and the AOWS database.
8. Alarm Manager shall provide a user customizable navigation link from the Alarm message to the data display or template to the equipment associated with the alarm.
9. Alarm Manager shall provide a context menu that will allow for navigation to Schedule, Trendlog, Object Property display, or System (user) Activity from the Alarm points live data value.
10. AOWS shall include an Alarm Wizard for set up of alarms. Wizard shall walk user through all steps necessary for alarm generation. Wizard shall have its own pull-down selection for startup or may be started by right-clicking on value displayed on graphic and then selecting alarm setup.
11. User can silence audible annunciation for the current session.
12. User can disable auto-refresh of alarm annunciation for current session.
13. Any displayed data that is changeable by the operator may be selected using the right mouse button and the alarm shall then be selectable on the screen. Selection of the alarm using this method shall allow the viewing of the alarm history or allow the creation of a new alarm.
14. Alarm Priority Levels (0-127) shall be definable in number and name. Alarms can be assigned to any of the priority levels defined.
15. The following Alarm data shall be displayed in the Alarm Management User Interface for each alarm:
  - a. Number of times the alarm has occurred
  - b. Average alarm duration (hours, minutes, and seconds) for the following transitions:
    - 1) Active to Normal
    - 2) Active to Acknowledgement
    - 3) Acknowledgement to Normal
  - c. Actual alarm duration (hours, minutes, and seconds) for the following transitions for each alarm occurrence:

- 1) Active to Normal
- 2) Active to Acknowledgement
- 3) Acknowledgement to Normal
- d. Live data point of point alarmed
- e. Navigation link to a user-selected display or URL
16. User Comment text shall be entered upon acknowledgement of an Alarm. The comment history is stored in the system data base and a user cannot edit or delete a comment after it has been submitted in the system.
17. Alarm Performance: An alarm annunciation shall appear on the AOWS user interface within 8 seconds and appear in the Alarm manager and data base within 10 seconds of a triggered alarm.
- L. Trendlog Information: Display trendlog records in standard engineering units.
  1. Periodically gather data stored in building controllers and store information in system database. Append stored records with new data. Overwriting records is not allowed unless file size is limited. System database capable of storing 50 million records before archiving data. Samples viewable at Web Client.

**\*\* NOTE TO SPECIFIER \*\* A SQL database must be used to meet the 50 million records level. Change to the following if specifying standard database "System database shall be capable of storing up to 30,000 records before needing to archive data."**

- a. Capable of trending on interval determined by polling rate, or change-of-value.
2. Add and edit trendlogs and setup information including the following:
  - a. The interval at which it is to be logged.
  - b. Operations shall be password protected.
  - c. Accessed directly from graphics on which a trended object is displayed.
3. Trendlog Wizard: Setup of multiple trend logs simultaneously. Walk users through necessary steps. Have a pull-down selection for startup, or by right-clicking on value displayed on graphic, and then selecting Trendlogs from displayed menu.
4. Trendlog Data: Viewable on Datalogger accessible via Web Browser. Trend logs of any point on a graphic must be initiated by performing a right mouse click on the point.
- M. DataViewer access via Web Browser: Capable of graphing trend-logged object data.
  1. Access and ability to create, edit and view are restricted by user account credentials
  2. Specific and repeatable URL defines trendlog views for browser bookmarking and email compatibility.
  3. Call out of trendlog value at intersection of trend line and mouse-over vertical axis.
  4. Trendlog or Energy log and companion logs configurable to display on one of two independent vertical scales embedded in display.
  5. Click zoom for control of data set viewed along either graph axis.
  6. User-specifiable start and end dates and fast scroll features supporting click zoom of macro scale view of data for quickly finding data set based on visual signature.
  7. User export of the viewed data set to MS Excel.
  8. Optional min/max ranges (Upper Control Limits, Lower Control Limits) for each value.
- N. Energy Log Information: Display information in standard engineering units.
  1. Periodically gather energy log data in field controller and archive information. Append files with new data. Overwriting archived data is not allowed unless file size is limited.
  2. Store data in database format for use by third-party programs. System operation to stay online during graphing operations.
  3. Operators to be able to change energy log setup information. Includes meters, meter pulse value, and type of energy units. Meters monitored by system may be logged.

- Support using flow and temperature sensors for BTU monitoring.
4. Web Client: Display data in tabular and graphical formats. Display in hourly, daily, weekly, monthly and yearly formats. Be able to select specific data periods to view.
- O. Demand Limiting: Sheds and restores equipment based on energy usage when compared to shed and restore settings.
1. Shedding: Implemented independently on each zone or piece of system equipment.
  2. Binary Shedding: 5 priority levels. Loads in a given priority level to be shed before any loads in a higher priority level are shed. Load shedding within a given priority level includes two methods; a "first off-first on" mode, and a "first off-last on" linear mode.
  3. Analog Shedding: Program generated ramp used by individual zones or control algorithm to raise and lower cooling and heating settings reducing energy usage.
  4. Status of each program to be displayed with description of each load on Web Client.
- P. Tenant Activity: A program monitoring after-hours overrides by tenants, logs data, and generates bill based on usage and rate charged for each tenant space.
1. Tenant after-hours override usage is logged in Operator Workstation database.
  2. Include entry of following information for use in logging and billing.
    - a. Tenant's contact name and address.
    - b. One or multiple tenant zones making up a total tenant space, including separate billing rate for each separate zone.
    - c. Minimum and maximum values an event duration and event limit.
    - d. Property management information.
    - e. Overall billing rate.
    - f. Seasonal adjustments or surcharge to billing rate.
    - g. Billing notification type including, but not limited to printer, file and email.
    - h. Billing form template.
  3. Logging: Include recording the following information for each and every tenant event.
    - a. Zone description.
    - b. Time the event begins.
    - c. Total override time.
    - d. Limits shall be applied to override time.
  4. A Tenant Bill: Generated for a specific period using entered configuration data and logged data. User with appropriate security level will be able to view and override billing information. User to be able to select a billing period to view and be able to delete events from billing and edit a selected tenant activity event's override time.
- Q. Reports: Capable of producing the following reports. Deliverable Format: CSV.
1. Trendlog configurations.
  2. Alarm configurations.
  3. Tenant activity configurations.
  4. Device summary.
  5. Energy log configurations.
  6. Schedule configurations.
  7. Deliverable Format: CSV files.
- R. Field Engineering Tools: For programming controllers supplied.
1. Database Application Manager: Include controller logic files and associated graphics.
  2. Device Manager: Detect devices connected on BACnet network by scanning. Display device instance, network ID, model, and description. Record and display software file loaded in each controller. Store file copies in project folder on computer's hard drive.

3. Audit when device not in database is added to network.
  4. Backup/restore function for system to selected medium. System to be capable of restoring systems and creating a backup for instantiating a new client PC.
  5. A means to scan, detect, interrogate, and edit third-party BACnet devices and BACnet objects within those devices.
- S. Web Interface: System software based upon server/thin client architecture, designed around open standards of web technology.
1. Communicate using Ethernet and TCP. Access server using a web browser across Owner's intranet and remotely via the Internet. Support 200 users with single license.
  2. Web Browser: Microsoft Edge v95 or later, Firefox v70 or later, Chrome v95 or later, and Safari 13 or later. No special vendor-supplied software to be required. Display data in real-time. Update automatically without user interaction.
  3. Web Pages: Automatically generated with HTML5 from data display files on Operator Workstation. Do not use systems requiring an HTML editor for web page generation.
  4. Launching Web Browser on Operator Workstation presents a login page requiring a login name and password. Navigation and system adjustments dependent upon operators assigned privileges. User activity reports will show activity of operators, whether changes were made using a web client or Operator Workstation.
  5. User Session Management including ability to view connected user sessions to the web client, see how long they have been active/inactive for each unique session, and force log-out for any or all sessions.
- T. Context Menu Navigation: Web Browser: Support Context Menu Navigation via a right mouse click on a data point.
1. Operations to be dependent upon logged in user privileges and include:
    - a. View and setup Alarms.
    - b. View and setup Trend Logs.
    - c. Display the BACnet properties for the selected Object.
    - d. View and setup Schedules.
    - e. View System activity for the selected Object.
- U. Summary Pages:
1. Present system data in tabular form. Data to be from multiple devices. Points presented horizontally and devices listed on left side of table.
  2. Built using spreadsheet that can be imported into Operator Workstation.
  3. Data in summary pages to be live. Configure each object to be read only or writeable.
  4. Both analog and binary data shall be supported.
  5. Summary page, when populated, captured for archiving and review for analysis.
  6. The data shall be sortable by clicking on the column headings.
- 2.4 BUILDING CONTROLLER (ACM)
- A. General Requirements:
1. BACnet Conformance: Approved by BTL as meeting BACnet Building Controller (B-BC) profile requirements as defined by BTL Revision 15.
    - a. Refer to ANSI/ASHREA 135, for a complete list of the services that must be directly supported to provide for the profile listed above.
    - b. Proprietary services, if used, shall be documented and provided as part of submittal data. Tools shall be provided for working with proprietary information.
  2. Scalable: Number of trunks and protocols selectable to fit project requirements
  3. Capable of panel-mounting on DIN rail and/or via mounting screws.
  4. Global control strategies based on information from any objects in system, regardless

- if object is directly monitored by building controller module or by another controller.
5. Shall support configuration of 5 additional independent Building Controller Modules.
    - a. Additional Building Controller Modules shall support configuration as a BACnet Global Controller, BACnet Expandable I/O Controller, Modbus/BACnet Gateway, or Proprietary Protocol/BACnet Gateway as defined herein.
    - b. Each Building Controller Module supports running an independent DDC Program strategy.
    - c. Independent DDC Program control strategies shall run simultaneously, and modification of one control strategy shall not interrupt function or runtime of any of the other running Independent DDC Program control strategies.
  6. Software implementing DDC strategies shall be completely flexible and user definable.
  7. Software Programming Tools: Shall be provided as part of project software. Factory pre-programmed global strategies not modifiable by field personnel are not acceptable. Changing global strategies via firmware changes is also unacceptable.
  8. Programming: Object-oriented control function blocks and support DDC functions. Flowcharts: Generated and automatically downloaded to controller. Programming tool to be resident on workstation. This same tool shall be used for all controllers.
  9. Graphically view inputs and outputs of each program block in real-time as program is executing. Function may be performed using operator's workstation or field computer.
  10. Controller: 6,000 Analog Values and 6,000 Binary Values.
  11. Controller IP configuration: Via direct USB connect or field computer.
  12. Quad Core 996 Ghz processor to ensure fast processing speeds.
  13. Execute control algorithms and automated control functions with 64-bit processor.
  14. Minimum of 1 GB of DDR3 SDRAM on a 533 Mhz bus to ensure high speed data recording, large data storage capacity and reliability.
  15. Building Controller shall be provided with two on-board EIA-485 ports capable of supporting various EIA-485 protocols including, but not limited to, BACnet MS/TP and Modbus.
  16. Building Controller shall be provided with two independently configurable Ethernet ports. Both Ethernet ports shall be capable of supporting Ethernet speeds of 10Mbps, 100Mbps, and 1000Mbps. Both Ethernet ports shall support the following protocols at a minimum: BACnet/IPv4, BACnet/IPv6, Modbus TCP, TCP/IP, Lon/IP, and FOX.
  17. Ports capable of having protocols assigned shall utilize the respective port's physical connection.
  18. Building Controller shall be provided with a minimum of 2 binary (digital) inputs and 2 universal analog inputs selectable between 10K thermistor (Type II), 1k Platinum RTD (PT-1000), 0-10 VDC, 0-20 mA, and 0-10k Ohms. Each analog input shall be freely scalable, in real time, via a graphic user interface.
  19. Schedules:
    - a. Building Controller shall support normal seven-day scheduling, holiday scheduling and event scheduling.
    - b. Building Controller shall support a minimum of 384 BACnet Schedule Objects and 384 BACnet Calendar Objects.
    - c. Scheduling shall support Optimum Start Algorithm as defined herein.
    - d. All Schedule Objects shall be individually configurable to write on a change of state or on a defined interval of 300 seconds minimum to 900 seconds maximum.
  20. Logging Capabilities:

- a. Building Controller shall support a minimum of 2,000 trendlogs. Any object in the system (real or calculated) may be logged. Trendlogs shall be individually configurable for interval time sampling or change of state sampling (binary objects) or change of value sampling (analog objects). Sample time interval shall be adjustable at the operator's workstation.
  - b. Building Controller shall support a minimum of 1,000 COV subscriptions, excluding analog objects with no COV\_Increment property.
  - c. Viewed logs on-site or off-site using WAN or remote communication.
  - d. Periodically upload trended data to operator's workstation for archiving. Archived data available for use in spreadsheet or database programs.
21. Alarm Generation: Within the system for any object change of value or state, includes analog and binary object state changes, and controller communication failures.
- a. Each alarm may be dialed out as noted elsewhere.
  - b. Provide alarm log for alarm viewing. Log may be viewed on-site at operator's terminal or off-site using remote communications.
  - c. Handle up to 2,000 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.
22. Demand Limiting of Energy:
- a. Building Controller shall support a minimum of 10 user-configurable Demand-Limiting/Load Shedding Controller modules.
  - b. Demand-Limiting/Load Shedding Controller modules shall support shedding of at least 1,200 analog and binary loads.
  - c. Demand-Limiting/Load Shedding Controller modules shall operate as defined herein.
23. Tenant Activity Logging:
- a. Building Controller shall support Tenant Billing Control Modules per independent Building Controller Module.
  - b. Each independent Building Controller Module shall support a minimum of 384 zones.
  - c. Tenant Activity logging to function as defined herein.
- B. BACnet MS/TP:
- 1. BACnet MS/TP LAN must be software-configurable from 9.6 to 115.2 Kbps
    - a. Each BACnet MS/TP LAN shall support 64 BACnet devices at a minimum.
    - b. Proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
- C. BACnet IP and BACnet Ethernet:
- 1. The Building Controller shall, at a minimum, comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the local area network (LAN).
  - 2. The Building Controller shall be capable of being configured to communicate using the following BACnet communication protocols simultaneously:
    - a. BACnet/Ethernet.
    - b. BACnet/IPv4.
    - c. BACnet/IPv6.
  - 3. Must support interoperability on WANs and campus area networks (CANs), and function as a BACnet Broadcast Management Device (BBMD).
  - 4. Each controller shall support at a minimum 128 BBMD entries.

5. BBMD management architecture shall support 3,000 subnets at a minimum.
  6. Shall support BACnet Network Address Translation.
  7. Proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
- D. Expansion Ports:
1. Controller shall support two (2) expansion ports.
    - a. Combining the two on-board EIA-458 ports with fully loaded expansion ports, the controller shall support a maximum of six (6) EIA-485 trunks simultaneously.
  2. Expansion Cards: Mate to the expansion ports, shall include the following.
    - a. Dual port EIA-485 card.
    - b. Single port EIA-232 card
    - c. 78 kbps FTT10A LON network card.
- E. Modbus Protocol Support:
1. Controller shall support reading from and writing to TCP Slaves and Serial Connections (RTU or ASCII over either EIA-485 or EIA-232).
    - a. Shall be capable of mapping Modbus register coil data to BACnet AV, BV, MV, AI, BI, and MI object types.
    - b. Support a minimum of 6000 Mapped Modbus points.
    - c. Modbus over EIA-485 shall be software-configurable from 9.6 to 115.2 Kbps
  2. Support up to 384 virtual groupings of Modbus points where each grouping is represented as a single virtual BACnet device.
    - a. Virtual BACnet devices support BACnet Change Of Value (COV) notifications
    - b. Each Virtual device has diagnostic information for troubleshooting Modbus point mapping. Diagnostic point should include the following.
      - 1) Number of points mapped.
      - 2) Number of messages Transmitted and Received.
      - 3) Modbus Exception Counts.
      - 4) Display of last exception message.
      - 5) Serial Setting (Baud rate, Parity, Stop Bits).
  3. Integration Performance:
    - a. Data age of integrated point shall be capable of 1 second for 5000 points.
    - b. Polling Interval shall be adjustable per Modbus Device, up to a maximum (fastest) polling interval of 1 second.
    - c. Maximum Registers per Message shall be adjustable per Modbus device within a range of 1 to 100.
- F. Niagara Framework:
1. Controller shall utilize the Tridium Niagara Framework.
    - a. Niagara Framework shall be version N4.8 or newer.
    - b. Niagara licensing shall be stored on a removable MicroSD card for fast in-field replacement of controller.
  2. The Niagara License for the controllers shall be an open license.
    - a. The controller shall be programmable via Niagara Workplace programming tool.
    - b. The controller shall be programmable via a Niagara embedded Workplace programming tool.
- G. Power Supply:

1. Input for power: Accept between 17 and 30 VAC, 47 and 63 Hz.

**\*\* NOTE TO SPECIFIER \*\* Delete subparagraph below if rechargeable battery not required.**

2. Rechargeable Battery: For controller shutdown including flash memory data storage.
  3. On-board capacitor ensuring continuous operation of real-time clocks for 14 days.
- H. Controller: Shall be in compliance with the following.
1. UL 916 for open energy management.
  2. FCC Class B.
  3. RoHS Compliant.
  4. IEC 60703.
  5. C-Tick Listed.
  6. CE(EN 60730-1).
- I. Controller: Operate in the following environmental conditions.
1. Without Battery: Minus 4 to 149 degrees F (Minus 20 to 65 degrees C).
  2. With Battery: 32 to 122 degrees F (0 to 50 degrees C).
  3. Relative Humidity: 0 to 95 percent, non-condensing.

**\*\* NOTE TO SPECIFIER \*\* The Article below is only needed for projects where expandable/standalone central plant and AHU controllers are required. Delete for all other projects.**

## 2.5 CENTRAL PLANT AND AIR HANDLER APPLICATION CONTROLLERS (ACM/AXM)

### A. General Requirements:

1. One or more native BACnet application controller for each air handler and as needed for central plant control to adequately cover objects listed in object list.
2. Interface to building controller through Ethernet LAN using BACnet over Ethernet or BACnet/IPv4 or BACnet/IPv6. No Gateways shall be used.
3. Include input, output and self-contained logic program as needed for complete control of units. Fully programmable using graphical programming blocks. Resident programming tool on operator workstation. Same tool used for all controllers. No auxiliary or non-BACnet controllers shall be used.

### B. BACnet Conformance:

1. BACnet Conformance: Approved by BTL as meeting BACnet Building Controller (B-BC) profile requirements as defined by BTL Revision 15.
2. Refer to ANSI/ASHREA 135, for a complete list of services directly supported to provide each of the functional groups listed. Proprietary services, to be documented and provided in submittal data. Supply tools for working with proprietary information.
3. Object types supported include, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Multi-state Values, Device, File, and Program object types. Proprietary types, to be documented and provided in submittal data. Supply tools for working with proprietary information.

### C. Direct Digital Controls:

1. Include universal inputs with 12-bit resolution that accept 3K and 10K thermistors, 0 to 10 VDC, Platinum 1000 ohm RTD, 0 to 5 VDC, 4 to 20 mA and dry contact signals. Inputs on controllers may be analog or digital. A minimum of 3 inputs that accept pulses. Include binary and analog outputs on board. Analog outputs with 12-bit resolution to support either 0 to 10 VDC or 0 to 20 mA. Binary outputs: LED indication of status. Software must include scaling features for analog outputs. Include 20 VDC for use as power supply to external sensors.
2. Outputs must have onboard Hand-Off-Auto (HOA) switches and status indicator light. Monitor HOA switch position. Analog outputs will include potentiometer for manual adjustment of output when HOA switch is in Hand position.

3. The position of each and every HOA switch shall be available system wide as a BACnet object property.
- D. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. Program sequences shall be executed by controller up to 1 time per second. Program shall be capable of multiple PID loops for control of multiple devices. Calculations shall be completed using floating-point math and system shall support display of information in floating-point nomenclature at operator's terminal.
1. The following program function blocks shall be supported.
    - a. 8-Input Average
    - b. 8-Input AND
    - c. 8-Input OR
    - d. 2-Point Linear Converter
    - e. Delay on Make with Reset & Suspend
    - f. Delay on Break with Reset and Suspend
    - g. Astronomical Clock (sunrise/sunset calculation).
    - h. Time based schedules.
    - i. Natural Log.
    - j. Exponential.
    - k. Log base 10.
    - l. X to the power of Y.
    - m. Nth square root of X.
    - n. 5th Order Polynomial Equations.
    - o. Multi-Trigonometric
    - p. ATAN2
    - q. Floor/Ceiling/Round
    - r. Absolute Value
    - s. Psychrometric Chart
    - t. Atmospheric Pressure Calculator
    - u. Interpolate
    - v. Bit Unpack
    - w. Bit Pack
    - x. Choose Highest/Lowest Score (Rotation Sequencing)
  2. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using programming tools as described in Operator's Workstation section.
- E. Schedules: The controller shall support a minimum of 3 BACnet Schedule Objects and have a real time clock on board with battery backup to maintain time through a power loss.
- F. Logging Capabilities:
1. Controller shall support a minimum of 50 trendlogs. Any object in the controller (real or calculated) may be logged. Sample time interval shall be adjustable at the Operator's Workstation.
  2. Controller shall periodically upload trended data to system server for long-term archiving if desired. Archived data stored in SQL database form and shall be available for use in third-party spreadsheet or database programs.
- G. Alarm Generation:

1. Alarms may be generated within the controller for any object change of value or state (either real or calculated). This includes things such as analog object value changes, and binary object state changes.
  2. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.
  3. Controller must be able to handle up to 25 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.
- H. Power Supply:
1. Input for power shall accept between 17 and 30 VAC, 47 and 63 Hz.
  2. Power Input/Output expansions separate and shall be 24 VAC 50/60 Hz, 20 VA minimum and half-wave rectified. Output loads are powered separately.
  3. Optional rechargeable battery for shutdown of controller including storage of data in flash memory.
  4. On-board capacitor will ensure continuous operation of real-time clocks for minimum of 14 days.
- I. Controller: Shall be in compliance with the following.
1. UL 916 for open energy management
  2. FCC Part 15 Class B
  3. ICES-003 Issue 6
  4. EN 60703-1
- J. The controller processor shall be a 64-bit processor.
- K. The packaging of the controller shall provide operable doors to cover the terminals once installation is complete. The housing of the controller shall provide for DIN rail mounting and also fully enclose circuit board.

**\*\* NOTE TO SPECIFIER \*\* The Article below is only needed for projects where expandable/standalone central plant and AHU controllers are required that specifically need to support IPV6 or Ethernet Communications. Delete for all other projects.**

## 2.6 EXPANDABLE ADVANCED APPLICATION CONTROLLERS (VIP-363-HOA)

- A. General Requirements:
1. Provide control strategies for system based on information from connected inputs. Program implementing strategies to be fully programmable, completely flexible and user-definable.
  2. An onboard real-time clock must support schedule operations and trendlogs. Conform to B-BC BACnet specification, with 24-hour power fail backup.
  3. Control algorithms and automated control functions: Use 32-bit processor.
  4. A built in 4-port Gigabyte switch supporting 10/100/1000 Base-T. Up to three Ethernet ports to be disabled via software configuration if required.
    - a. Support the following ethernet network topologies and protocols:
      - 1) Star.
      - 2) Daisy Chain.
      - 3) Ring.
      - 4) Rapid Spanning Tree Protocol
  5. Expandable Advanced Application Controller shall be configurable to communicate using any of the following BACnet protocols:
    - a. BACnet/Ethernet.
    - b. BACnet/IPv4.
    - c. BACnet/IPv6.
  6. Base unit of controller shall be capable of hosting a minimum of 8 Input/Output

expansion modules with various I/O combinations.

7. Support for intelligent room sensor. Room sensor display to be programmable at controller and include operating and field service modes. Button functions and display data to be programmable to show specific controller data in each mode based on which button is pressed on the sensor.
  8. Provide 172 discreet inputs/outputs per base unit.
  9. Expandable Advanced Application Controller to have a visual indicator (LED) of device status.
    - a. No power to controller.
    - b. Unit Initializing.
    - c. Firmware running with no I/O communicating.
    - d. Firmware running with I/O communicating.
- B. Direct Digital Controls:
1. Provide means to graphically view inputs and outputs on each program block in real-time as program is executing. This function may be performed using the Operator Workstation.
  2. Expandable Advanced Application Controller and Expansion Input/Output Modules shall include universal inputs with 16-bit resolution selectable between 10K thermistors (Type II and III), 1k Platinum RTD, 0-10 VDC, 0-20 mA, dry-contact, and dry-contact pulse input signals. Dry-contact pulse inputs shall support a maximum frequency of 100 Hz with a minimum duty-cycle of 5ms ON and 5ms OFF. Each analog input shall be freely scalable, in real time, via a graphic user interface.
  3. Expandable Advanced Application Controller and Expansion Input/Output Modules shall include binary and analog outputs on board. Binary outputs shall be solid-state relays rated 20-30 VDC @ 50/60 Hz, 1.0 A continuous, 3.5 A inrush for 100 ms. Analog outputs shall be 16-bit resolution and support voltage, current, and binary modes. Voltage mode shall provide 0-10 VDC @ 10mA maximum (1k ohm minimum). Current mode shall provide 4-20 mA @ 550 ohms maximum. Binary mode shall provide 12 VDC @ 20 mA maximum relay coil current for controlling low-coil current 12 VDC relays and solid-state relays. Each analog output shall be freely scalable, in real time, via a graphic user interface.
  4. Expandable Advanced Application Controller and Expansion Input/Output Modules shall include 20 VDC voltage supply for use as power supply to external sensors.
  5. All binary and analog outputs shall have onboard Hand-Off-Auto (HOA) switches and a status indicator light. HOA switch position shall be monitored. Each analog output shall include a potentiometer for manually adjusting the output when the HOA switch is in the Hand position.
  6. The position of each and every HOA switch and analog output potentiometer values shall be available system wide as a BACnet object property.
  7. Expansion Input/Output Modules shall be capable of being installed directly connected to Expandable Advanced Application Controller or installed remotely connected via cable to Expandable Advanced Application Controller. Remote installation shall support a distance between controller and module of 4,000 feet.
  8. Expandable Advanced Application Controller shall, at a minimum, include 3 Universal Inputs, 6 Binary Outputs, and 3 Universal inputs/outputs. Universal inputs/outputs shall be independently configurable to operate as any input or output type described above.
  9. Expansion Input/Output Modules shall, at a minimum, include 3 Universal Inputs, 3 Binary Outputs, and 2 Universal inputs/outputs. Universal inputs/outputs shall be independently configurable to operate as any input or output type described above.
- C. Programmable Controller:

1. Programming shall be object-oriented using control program blocks. Controller shall support a minimum of 120 Analog Values and 100 Binary Values. Up to 50 analog and binary values shall support standard BACnet priority arrays. Programming tool shall be provided with the Operators Workstation and shall be the same tool that is used to program the expandable advanced application controller.
  2. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. Program sequences shall be executed by controller up to 1 time per second. Program shall be capable of multiple PID loops for control of multiple devices. Calculations shall be completed using floating-point math and system shall support display of information in floating-point nomenclature at operator's terminal.
  3. The following program function blocks shall be supported.
    - a. 8-Input Average
    - b. 8-Input AND
    - c. 8-Input OR
    - d. 2-Point Linear Converter
    - e. Delay on Make with Reset & Suspend
    - f. Delay on Break with Reset and Suspend
    - g. Astronomical Clock (sunrise/sunset calculation).
    - h. Time based schedules.
    - i. Natural Log.
    - j. Exponential.
    - k. Log base 10.
    - l. X to the power of Y.
    - m. Nth square root of X.
    - n. 5th Order Polynomial Equations.
    - o. Multi-Trigonometric
    - p. ATAN2
    - q. Floor/Ceiling/Round
    - r. Absolute Value
    - s. Psychrometric Chart
    - t. Atmospheric Pressure Calculator
    - u. Interpolate
    - v. Bit Unpack
    - w. Bit Pack
    - x. Choose Highest/Lowest Score (Rotation Sequencing)
  4. Programming of expandable advanced application controller shall be completely modifiable in the field over installed BACnet LANs. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Expandable advanced application controller shall be programmed using programming tools as described in Operator's Workstation section.
- D. Schedules:
1. Expandable Application Controller shall support a minimum of 50 BACnet Schedule Objects.
    - a. All Schedule Objects shall be individually configurable to write on a change of state or on a defined interval of 300 seconds minimum to 900 seconds maximum.
  2. Scheduling shall support Optimum Start Algorithm as defined herein.

- E. Logging Capabilities:
  - 1. Expandable Advanced Application Controller shall support trendlogs. Any object in the controller (real or calculated) may be logged. Trendlogs shall be individually configurable for interval time sampling or change of state sampling (binary objects) or change of value sampling (analog objects). Sample time interval shall be adjustable at the operator's workstation.
  - 2. Controller shall periodically upload trended data to system server for long-term archiving if desired.
  - 3. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.
- F. Alarm Generation:
  - 1. Expandable Advanced Application Controller shall support a minimum of 100 alarms.
  - 2. For any object change of value or state (either real or calculated); analog object value changes, binary object state changes, and controller communication failures.
  - 3. Alarm log: Provided for viewing operator's terminal or off-site with remote access.
  - 4. Controller must handle alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.
- G. BACnet Conformance:
  - 1. The Expandable Advanced Application Controller shall, support Ethernet BACnet LAN types. It shall communicate directly through these BACnet LANs as a native BACnet device. Controllers shall be approved by the BTL as meeting BACnet Building Controller requirements as defined under BTL Revision 18.
  - 2. Refer to ANSI/ASHRAE 135, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. Proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
  - 3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Binary Input, Analog Output, Binary Output, Analog Value, Binary Value, Device, File, Group, Event Enrollment, Notification Class, Program, and Schedule object types. Necessary tools shall be supplied for working with proprietary information.
  - 4. The Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN.
  - 5. The Expandable Advanced Application Controller shall have the ability to:
    - a. Be disabled from traffic to and from other subnets.
    - b. Subscribe to COV subscriptions at a definable interval.
- H. Security:
  - 1. The Expandable Advanced Application Controller shall be configured with passwords of eight or more characters for:
    - a. Console configuration.
    - b. Backup and restore.
    - c. Disable traffic to and from other subnets.
    - d. Protect backup/restore/restart.
- I. Power Supply: Input for power shall accept between 20 and 30 VAC, 50/60 Hz. Half wave rectified. Output loads are powered separately.
- J. Controller shall be in compliance with the following:
  - 1. UL 916 for open energy management.

2. UL 2403 for installation in air handling spaces and plenums
  3. FCC Part 15 Subpart J, Class A.
  4. EMC Directive 89/336/EEC.
- K. Controller shall operate in the following environmental conditions:
1. Minus 4 to 131 degrees F (Minus 20 to 55 degrees C).
  2. 0 to 95 percent relative humidity (RH), non-condensing.

**\*\* NOTE TO SPECIFIER \*\* The Article below is only needed for projects where VAV controllers are required that specifically need to support IPV6 or Ethernet Communications. Delete for all other projects.**

- 2.7 UNITARY IP over ETHERNET CABLE or T1L CONTROLLERS (VLC8u8-IP, VLC16u8-IP, VLC8u8-T1L, VLC16u8-T1L)
- A. General Requirements:
1. The Unitary IP controller shall be capable of providing control strategies for the system based on information from any or all connected inputs. The program that implements these strategies shall be fully programmable, completely flexible and user definable. Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site though simple download are not acceptable.
  2. An onboard real-time clock must support schedule operations and trendlogs. The real-time clock shall conform to B-AAC BACnet specification, with 24-hour power fail backup.
  3. Control algorithms and automated control functions should execute using a 32-bit processor.
  4. Unitary IP Controller shall include a built in 2-port Ethernet switch capable of supporting 10/100 Base-T or two 10BASE-T1L (IEEE 802.3cg-2019) screw terminal termination points for single twisted pair, depending on model and use.
    - a. T1L Models require a T1L media Adapter (10BASE-T1L-ADAPT)
      - 1) The adapter shall connect via CAT6 cable to the front of line switch
      - 2) Single twisted pair shall connect to the adapter and carry ETHERNET protocol to the T1L controller.
  5. The built in 2-port switch shall support the following ethernet network topologies and protocols:
    - a. Home-run
    - b. Daisy Chain – T1L must support fail-safe daisy chains with distances between devices of at least 300m and up to 1000m.
    - c. Ring with Rapid Spanning Tree Protocol (RSTP)
  6. BACnet communication over Ethernet and protocols shall include:
    - a. BACnet/Ethernet
    - b. BACnet/IPv4
    - c. BACnet/IPv6
  7. IP addressing modes shall include Static, DHCP, and SLAAC
  8. Networking Protocols shall include Rapid Spanning Tree (RSTP) and Network Time (NTPv4)
  9. Unitary IP Controller shall include support for intelligent room sensor. Display on room sensor shall be programmable at controller and include an operating mode and a field service mode. Button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.
  10. Unitary IP Controller shall have a visual indicator (LED) of the status of the device

- a. BACnet transmit (Tx) and receive (Rx)
  - b. Firmware downloading
  - c. No application program (DDC) loaded
  - d. Open or shorted input/output
  - e. Normal operation
  - f. Intelligent room sensor communication error
- B. Direct Digital Controls:
1. Provide means to graphically view inputs and outputs on each program block in real-time as program is executing. This function may be performed using the Operator Workstation.
  2. Unitary IP Controller shall include 8 or 16 Universal inputs/outputs. Universal inputs/outputs shall be independently configurable to operate as any input or output type.
    - a. Shall include 4 x relays with SPDT contacts, providing up to 12 A constant combine current.
    - b. Shall include 4 x 24VAC/VDC solid state relay outputs with 1.5 A continuous and 3.5 A in-rush for 100 milliseconds per output.
  3. Unitary IP Controller shall provide universal inputs/outputs with 16-bit resolution that can be configured to be an analog or binary input, as follows:  
selectable between 10K thermistors (Type II and III), 1k Platinum RTD, 0-10 VDC, 0-20 mA, dry-contact, and dry-contact pulse input signals. Dry-contact pulse inputs shall support a maximum frequency of 100 Hz with a minimum duty-cycle of 5ms ON and 5ms OFF. Each analog input shall be freely scalable, in real time, via a graphic user interface.
- C. Programmable Controller:
1. Programming shall be object-oriented using control program blocks. Controller shall support a minimum of 120 Analog Values and 100 Binary Values. Up to 50 analog and binary values shall support standard BACnet priority arrays. Programming tool shall be provided with the Operators Workstation and shall be the same tool that is used to program the controller.
  2. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. Program sequences shall be executed by controller up to 1 time per second. Program shall be capable of multiple PID loops for control of multiple devices. Calculations shall be completed using floating-point math and system shall support display of information in floating-point nomenclature at operator's terminal.
  3. The following program function blocks shall be supported.
    - a. 8-Input Average
    - b. 8-Input AND
    - c. 8-Input OR
    - d. 2-Point Linear Converter
    - e. Delay on Make with Reset & Suspend
    - f. Delay on Break with Reset and Suspend
    - g. Astronomical Clock (sunrise/sunset calculation).
    - h. Time based schedules.
    - i. Natural Log.
    - j. Exponential.
    - k. Log base 10.
    - l. X to the power of Y.

- m. Nth square root of X.
  - n. 5th Order Polynomial Equations.
  - o. Multi-Trigonometric
  - p. ATAN2
  - q. Floor/Ceiling/Round
  - r. Absolute Value
  - s. Psychrometric Chart
  - t. Atmospheric Pressure Calculator
  - u. Interpolate
  - v. Bit Unpack
  - w. Bit Pack
  - x. Choose Highest/Lowest Score (Rotation Sequencing)
4. Programming of controller shall be completely modifiable in the field over installed BACnet LANs. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Controller shall be programmed using programming tools as described in Operator's Workstation section.
- D. Logging Capabilities:
- 1. Controller shall support trendlogs. Any object in the controller (real or calculated) may be logged. Trendlogs shall be individually configurable for interval time sampling or change of state sampling (binary objects) or change of value sampling (analog objects). Sample time interval shall be adjustable at the operator's workstation.
  - 2. Controller shall periodically upload trended data to system server for long-term archiving if desired.
  - 3. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.
- E. Alarm Generation:
- 1. Controller shall support a minimum of 25 alarms and 5 alarm handlers.
  - 2. Alarms may be generated within the system for any object change of value or state (either real or calculated). This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
  - 3. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.
  - 4. Controller must be able to handle alarm setups stored as BACnet Event Enrollment objects, with system destination and actions individually configurable via BACnet Notification Class objects.
- F. BACnet Conformance:
- 1. Unitary IP Controller shall, support Ethernet BACnet LAN types. It shall communicate directly through these BACnet LANs as a native BACnet device. Controllers shall be approved by the BTL as meeting the BACnet Advanced Application Controller (B-AAC) requirements as defined under BTL Revision 18.
  - 2. Refer to ANSI/ASHRAE 135, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. Proprietary services, if used in the system, shall be thoroughly documented, and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
  - 3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Binary Input, Analog Output, Binary Output, Analog Value, Binary Value, Device, File, Group, Event Enrollment, Notification Class, Program, and Schedule object types. Necessary tools shall be supplied for working with proprietary information.

4. The Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN.
  5. Unitary IP Controller shall have the ability to:
    - a. Be disabled from traffic to and from other subnets.
    - b. Subscribe to COV subscriptions at a definable interval.
- G. Security: The controller to be configured with passwords of eight or more characters for:
1. Backup and Restore.
  2. Disable traffic to and from other subnets.
  3. Protect Backup/Restore/Restart.
- H. Power Supply: Input for power shall accept between 20 and 30 VAC, 50/60 Hz. Half wave rectified. Capability for separate power source shall be provided for binary output SSR loads.
- I. Controller to be in compliance with the Following:
1. FCC Part 15, Class A
  2. IC – ICES-003 Issue 6
  3. UL916, Energy Management Equipment
  4. Plenum tested (according to UL2043)
  5. RoHS
  6. EN 55022. Class A
  7. EN 61000-3-2, 61000
  8. CE
- J. Controller to operate in the following environmental conditions:
1. Storage -40 °F to 150 °F (-40 °C to 66 °C)
  2. Operation 32 °F to 122 °F (0 °C to 50 °C)
  3. Humidity 5% to 95% RH., non condensing
  4. Protection IP20, NEMA 1
  5. Pollution Level 2

## 2.8 ADVANCED VAV APPLICATION CONTROLLERS (VIP-363-VAV)

- A. General Requirements:
1. The Advanced VAV Application Controller shall be capable of providing control strategies for the system based on information from any or all connected inputs. The program that implements these strategies shall be fully programmable, completely flexible and user-definable. Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site though simple download are not acceptable.
  2. An onboard real-time clock must support schedule operations and trendlogs. The real-time clock shall conform to B-BC BACnet specification, with 24-hour power fail backup.
  3. Control algorithms and automated control functions should execute using a 32-bit processor.
  4. Advanced VAV Application Controller shall include a built in 4-port Gigabit switch capable of supporting 10/100/1000 Base-T. Up to three of the Ethernet ports shall be disabled via software configuration if required.
  5. The built in 4-port switch shall support the following ethernet network topologies and protocols:
    - a. Star.
    - b. Daisy Chain.

- c. Ring.
  - d. Rapid Spanning Tree Protocol (RSTP)
- 6. BACnet communication over Ethernet and protocols shall include:
  - a. BACnet/Ethernet.
  - b. BACnet/IPv4.
  - c. BACnet/IPv6.
- 7. The Advanced VAV Application Controller shall have an integral airflow sensor with the following characteristics and capabilities.
  - a. 16-bit A/D resolution.
  - b. Polarity insensitive.
  - c. 0.2 in wc (500 Pa) range.
  - d. 0.0004 in wc (0.1 Pa) zero-point accuracy.
  - e. 0.5% span repeatability
  - f. Barb fitting connection 0.125 inch diameter x 0.375 inch long
  - g. Field Replaceable.
- 8. Advanced VAV Application Controller shall include support for intelligent room sensor. Display on room sensor shall be programmable at controller and include an operating mode and a field service mode. Button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.
- 9. The Advanced VAV Application Controller shall have a visual indicator (LED) of the status of the device
  - a. No power to controller.
  - b. Unit Initializing.
  - c. Firmware running.
- B. Direct Digital Controls:
  - 1. Provide means to graphically view inputs and outputs on each program block in real-time as program is executing. This function may be performed using the Operator Workstation.
  - 2. Advanced VAV Application Controller shall include universal inputs with 16-bit resolution selectable between 10K thermistors (Type II and III), 1k Platinum RTD, 0-10 VDC, 0-20 mA, dry-contact, and dry-contact pulse input signals. Dry-contact pulse inputs shall support a maximum frequency of 100 Hz with a minimum duty-cycle of 5ms ON and 5ms OFF. Each analog input shall be freely scalable, in real time, via a graphic user interface.
  - 3. Advanced VAV Application Controller shall include binary and analog outputs on board. Binary outputs shall be solid-state relays rated 20-30 VDC @ 50/60 Hz, 1.0 A continuous, 3.5 A inrush for 100 ms. Analog outputs shall be 16-bit resolution and support voltage, current, and binary modes. Voltage mode shall provide 0-10 VDC @ 10mA maximum (1k ohm minimum). Current mode shall provide 4-20 mA @ 550 ohms maximum. Binary mode shall provide 12 VDC @ 20 mA maximum relay coil current for controlling low-coil current 12 VDC relays and solid-state relays. Each analog output shall be freely scalable, in real time, via a graphic user interface.
  - 4. Advanced VAV Application Controller shall include 20 VDC voltage supply for use as power supply to external sensors.
  - 5. All binary and analog outputs shall have onboard Hand-Off-Auto (HOA) switches and a status indicator light. HOA switch position shall be monitored. Each analog output shall include a potentiometer for manually adjusting the output when the HOA switch is in the Hand position.

6. The position of each and every HOA switch and analog output potentiometer values shall be available system wide as a BACnet object property.
  7. Advanced VAV Application Controller shall, at a minimum, include 3 Universal Inputs, 6 Binary Outputs, and 3 Universal inputs/outputs. Universal inputs/outputs shall be independently configurable to operate as any input or output type described above.
- C. Programmable Controller:
1. Programming shall be object-oriented using control program blocks. Controller shall support a minimum of 120 Analog Values and 100 Binary Values. Up to 50 analog and binary values shall support standard BACnet priority arrays. Programming tool shall be provided with the Operators Workstation and shall be the same tool that is used to program the advanced VAV application controller.
  2. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. Program sequences shall be executed by controller up to 1 time per second. Program shall be capable of multiple PID loops for control of multiple devices. Calculations shall be completed using floating-point math and system shall support display of information in floating-point nomenclature at operator's terminal.
  3. The following program function blocks shall be supported.
    - a. 8-Input Average
    - b. 8-Input AND
    - c. 8-Input OR
    - d. 2-Point Linear Converter
    - e. Delay on Make with Reset & Suspend
    - f. Delay on Break with Reset and Suspend
    - g. Astronomical Clock (sunrise/sunset calculation).
    - h. Time based schedules.
    - i. Natural Log.
    - j. Exponential.
    - k. Log base 10.
    - l. X to the power of Y.
    - m. Nth square root of X.
    - n. 5th Order Polynomial Equations.
    - o. Multi-Trigonometric
    - p. ATAN2
    - q. Floor/Ceiling/Round
    - r. Absolute Value
    - s. Psychrometric Chart
    - t. Atmospheric Pressure Calculator
    - u. Interpolate
    - v. Bit Unpack
    - w. Bit Pack
    - x. Choose Highest/Lowest Score (Rotation Sequencing)
  4. Programming of advanced VAV application controller shall be completely modifiable in the field over installed BACnet LANs. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Advanced VAV application controller shall be programmed using programming tools as described in Operator's Workstation section.
- D. Schedules:

1. Advanced VAV Application Controller shall support a minimum of 10 BACnet Schedule Objects.
    - a. All Schedule Objects shall be individually configurable to write on a change of state or on a defined interval of 300 seconds minimum to 900 seconds maximum.
  2. Scheduling shall support Optimum Start Algorithm as defined herein.
- E. Logging Capabilities:
1. Advanced VAV Application Controller shall support a minimum of 100 trendlogs. Any object in the controller (real or calculated) may be logged. Trendlogs shall be individually configurable for interval time sampling or change of state sampling (binary objects) or change of value sampling (analog objects). Sample time interval shall be adjustable at the operator's workstation.
  2. Controller shall periodically upload trended data to system server for long-term archiving if desired.
  3. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.
- F. Alarm Generation:
1. Advanced VAV Application Controller shall support a minimum of 100 alarms.
  2. Alarms may be generated within the system for any object change of value or state (either real or calculated). This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
  3. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.
  4. Controller must be able to handle alarm setups stored as BACnet Event Enrollment objects, with system destination and actions individually configurable.
- G. BACnet Conformance:
1. The Advanced VAV Application Controller shall, support Ethernet BACnet LAN types. It shall communicate directly through these BACnet LANs as a native BACnet device. Controllers shall be approved by the BTL as meeting the BACnet Building Controller (B-BC) requirements as defined under BTL Revision 18.
  2. Refer to ANSI/ASHRAE 135, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. Proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
  3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Binary Input, Analog Output, Binary Output, Analog Value, Binary Value, Device, File, Group, Event Enrollment, Notification Class, Program, and Schedule object types. Necessary tools shall be supplied for working with proprietary information.
  4. The Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN.
  5. The Advanced VAV Application Controller shall have the ability to:
    - a. Be disabled from traffic to and from other subnets.
    - b. Subscribe to COV subscriptions at a definable interval.
- H. Security: The advanced VAV application controller to be configured with passwords of eight or more characters for:
1. Console configuration.
  2. Backup and Restore.

3. Disable traffic to and from other subnets.
  4. Protect Backup/Restore/Restart.
  - I. Power Supply: Input for power shall accept between 20 and 30 VAC, 50/60 Hz. Half wave rectified. Output loads are powered separately.
  - J. Controller to be in compliance with the Following:
    1. UL 916 for open energy management.
    2. UL 2403 for installation in air handling spaces and plenums
    3. FCC Part 15 Subpart J, Class A.
    4. EMC Directive 89/336/EEC.
  - K. Controller to operate in the following environmental conditions:
    1. Minus 4 to 131 degrees F (Minus 20 to 55 degrees C)
    2. Relative Humidity: 0 to 95 percent non-condensing.
- 2.9 ADVANCED VAV APPLICATION CONTROLLER WITH INTEGRATED ACTUATOR (VAVi-7U5-IP)
- A. General Requirements:
    1. The Advanced VAV Application Controller with Integrated Actuator shall be capable of providing control strategies for the system based on information from any or all connected inputs. The program that implements these strategies shall be fully programmable, completely flexible and user definable. Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site though simple download are not acceptable.
    2. An onboard real-time clock must support schedule operations and trendlogs. The real-time clock shall conform to B-AAC BACnet specification, with 24-hour power fail backup.
    3. Control algorithms and automated control functions should execute using a 32-bit processor.
    4. Advanced VAV Application Controller shall include a built in 2-port Ethernet switch capable of supporting 10/100 Base-T.
    5. The built in 2-port switch shall support the following ethernet network topologies and protocols:
      - a. Home-run
      - b. Daisy Chain
      - c. Ring with Rapid Spanning Tree Protocol (RSTP)
    6. BACnet communication over Ethernet and protocols shall include:
      - a. BACnet/Ethernet
      - b. BACnet/IPv4
      - c. BACnet/IPv6
    7. IP addressing modes shall include Static, DHCP, and SLAAC
    8. Networking Protocols shall include Rapid Spanning Tree (RSTP) and Network Time (NTPv4)
    9. The Advanced VAV Application Controller shall have an integral airflow sensor with the following characteristics and capabilities.
      - a. 16-bit A/D resolution.
      - b. Polarity insensitive.
      - c. 0.2 in wc (500 Pa) range.
      - d. 0.0004 in wc (0.1 Pa) zero-point accuracy.
      - e. 0.5% span repeatability
      - f. Barb fitting connection 0.125 inch diameter x 0.375 inch long

- g. Field Replaceable.
10. The Advanced VAV Application Controller shall have an integral modulating actuator with analog position feedback. Actuator shall have the following specifications:
    - a. Torque: 44 in-lbs (5 Nm)
    - b. Run Time: 108 seconds at 50 Hz; 90 seconds at 60 Hz
    - c. Mounting shaft: Round 8-16 mm (5/16 – 5/8”); Square 6-13 mm (15/64-33/64”)
    - d. Shaft Length: ≥ 1 5/8 in (41 mm)
  11. Advanced VAV Application Controller shall include support for intelligent room sensor. Display on room sensor shall be programmable at controller and include an operating mode and a field service mode. Button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.
  12. The Advanced VAV Application Controller shall have a visual indicator (LED) of the status of the device
    - a. BACnet transmit (Tx) and receive (Rx)
    - b. Firmware downloading
    - c. No application program (DDC) loaded
    - d. Open or shorted input/output
    - e. Normal operation
    - f. Intelligent room sensor communication error
- B. Direct Digital Controls:
1. Provide means to graphically view inputs and outputs on each program block in real-time as program is executing. This function may be performed using the Operator Workstation.
  2. Advanced VAV Application Controller shall include 7 Universal inputs/outputs. Universal inputs/outputs shall be independently configurable to operate as any input or output type described below.
  3. Advanced VAV Application Controller shall provide universal inputs/outputs with 16-bit resolution that can be configured to be an analog or binary input, as follows:  
selectable between 10K thermistors (Type II and III), 1k Platinum RTD, 0-10 VDC, 0-20 mA, dry-contact, and dry-contact pulse input signals. Dry-contact pulse inputs shall support a maximum frequency of 100 Hz with a minimum duty-cycle of 5ms ON and 5ms OFF. Each analog input shall be freely scalable, in real time, via a graphic user interface.
  4. Advanced VAV Application Controller shall provide universal inputs/outputs that can be configured to be an analog or binary output, as follows:
    - a. Analog outputs shall be 16-bit universal analog outputs and support the following modes – Voltage Mode: 0-10 VDC @ 10 mA maximum (1k ohm minimum); Current Mode: 4-20 mA @ 550 ohms Maximum; or Binary Mode: 11 VDC @ 20 mA maximum relay coil current (for controlling low-coil current 11 VDC relays and solid-state relays.
    - b. Each analog output shall be freely scalable, in real time, via a graphic user interface.
  5. Advanced VAV Application Controller shall provide 5 binary outputs that shall be solid-state relays rated 20-30 VDC @ 50/60 Hz, 1.5 A continuous, 3.5 A inrush for 100 ms.
  6. Advanced VAV Application Controller shall include 20 VDC @ 75mA voltage supply for use as power supply to external sensors.
- C. Programmable Controller:

1. Programming shall be object-oriented using control program blocks. Controller shall support a minimum of 120 Analog Values and 100 Binary Values. Up to 50 analog and binary values shall support standard BACnet priority arrays. Programming tool shall be provided with the Operators Workstation and shall be the same tool that is used to program the advanced VAV application controller.
  2. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. Program sequences shall be executed by controller up to 1 time per second. Program shall be capable of multiple PID loops for control of multiple devices. Calculations shall be completed using floating-point math and system shall support display of information in floating-point nomenclature at operator's terminal.
  3. The following program function blocks shall be supported.
    - a. 8-Input Average
    - b. 8-Input AND
    - c. 8-Input OR
    - d. 2-Point Linear Converter
    - e. Delay on Make with Reset & Suspend
    - f. Delay on Break with Reset and Suspend
    - g. Astronomical Clock (sunrise/sunset calculation).
    - h. Time based schedules.
    - i. Natural Log.
    - j. Exponential.
    - k. Log base 10.
    - l. X to the power of Y.
    - m. Nth square root of X.
    - n. 5th Order Polynomial Equations.
    - o. Multi-Trigonometric
    - p. ATAN2
    - q. Floor/Ceiling/Round
    - r. Absolute Value
    - s. Psychrometric Chart
    - t. Atmospheric Pressure Calculator
    - u. Interpolate
    - v. Bit Unpack
    - w. Bit Pack
    - x. Choose Highest/Lowest Score (Rotation Sequencing)
  4. Programming of advanced VAV application controller shall be completely modifiable in the field over installed BACnet LANs. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Advanced VAV application controller shall be programmed using programming tools as described in Operator's Workstation section.
- D. Schedules:
1. Advanced VAV Application Controller shall support a minimum of 3 BACnet Schedule Objects. All Schedule Objects shall be individually configurable to write on a change of state or on a defined interval of 300 seconds minimum to 900 seconds maximum.
  2. Scheduling shall support Optimum Start Algorithm as defined herein.
- E. Logging Capabilities:
1. Advanced VAV Application Controller shall support a minimum of 50 trendlogs. Any

object in the controller (real or calculated) may be logged. Trendlogs shall be individually configurable for interval time sampling or change of state sampling (binary objects) or change of value sampling (analog objects). Sample time interval shall be adjustable at the operator's workstation.

2. Controller shall periodically upload trended data to system server for long-term archiving if desired.
3. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.

F. Alarm Generation:

1. Advanced VAV Application Controller shall support a minimum of 25 alarms and 5 alarm handlers.
2. Alarms may be generated within the system for any object change of value or state (either real or calculated). This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
3. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.
4. Controller must be able to handle alarm setups stored as BACnet Event Enrollment objects, with system destination and actions individually configurable via BACnet Notification Class objects.

G. BACnet Conformance:

1. The Advanced VAV Application Controller shall, support Ethernet BACnet LAN types. It shall communicate directly through these BACnet LANs as a native BACnet device. Controllers shall be approved by the BTL as meeting the BACnet Advanced Application Controller (B-AAC) requirements as defined under BTL Revision 18.
2. Refer to ANSI/ASHRAE 135, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. Proprietary services, if used in the system, shall be thoroughly documented, and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Binary Input, Analog Output, Binary Output, Analog Value, Binary Value, Device, File, Group, Event Enrollment, Notification Class, Program, and Schedule object types. Necessary tools shall be supplied for working with proprietary information.
4. The Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN.
5. The Advanced VAV Application Controller shall have the ability to:
  - a. Be disabled from traffic to and from other subnets.
  - b. Subscribe to COV subscriptions at a definable interval.

H. Security: The advanced VAV application controller to be configured with passwords of eight or more characters for:

1. Backup and Restore.
2. Disable traffic to and from other subnets.
3. Protect Backup/Restore/Restart.

I. Power Supply: Input for power shall accept between 20 and 30 VAC, 50/60 Hz. Half wave rectified. Capability for separate power source shall be provided for binary output SSR loads.

J. Controller to be in compliance with the Following:

1. FCC Part 15, Class A
2. IC – ICES-003 Issue 6

3. UL916, Energy Management Equipment
  4. Plenum tested (according to UL2043)
  5. RoHS
  6. EN 55022. Class A
  7. EN 61000-3-2, 61000
  8. CE
- K. Controller to operate in the following environmental conditions:
1. Storage -40 °F to 150 °F (-40 °C to 66 °C)
  2. Operation 32 °F to 122 °F (0 °C to 50 °C)
  3. Humidity 5% to 95% RH., non condensing
  4. Protection IP20, NEMA 1
  5. Pollution Level 2

## 2.10 TERMINAL UNIT APPLICATION CONTROLLERS (VLC-E and VAV-E)

### A. General Requirements:

1. One native BACnet application controller (B-ASC) for each piece of unitary mechanical equipment that adequately covers objects listed in object list for unit.
2. Interface to building controller through MS/TP LAN using BACnet protocol. No gateways to be used. Controllers to include input, output and self-contained logic program as needed for complete control of unit.
3. Microprocessor-based, multi-tasking, real-time digital control processor. Each controller shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network.
4. Sufficient memory to support system setpoints, proportional bands, control algorithms, and other programmable parameters shall be stored such that a power failure of any duration does not necessitate any reprogramming. Each application controller shall return to normal operation upon restoration of power.
5. Setpoint and input/output point data shall be accessible through any operator workstation, web browser and building controllers.
6. Ability to download and upload configuration data via the operator workstation.
7. One copy of any programming tool required to configure or program the controllers shall be provided to the Owner along with appropriate documentation.
8. Include 16-bit universal inputs auto-selectable between 3K and 10K thermistors, 0-5 VDC 0-10 VDC, 0-20 mA, dry contact, and pulse inputs. A minimum of 3 pulse inputs shall be provided. Any input on controller may be either analog or binary (digital). Controller shall also include support and modifiable programming for interface to intelligent room sensor. Pulse input shall measure a maximum frequency of 100 Hz, with a minimum duty cycle timing of 5 mS on and 5mS off. Signal selection for universal inputs shall not require on-board jumpers or DIP.
9. Include binary outputs and/or analog outputs as needed for the application. Binary outputs shall be integral to the controller and rated 24 VAC @ 50/60 Hz, 500 mA continuous and 800 mA (AC rms) for 60 milliseconds. Analog outputs shall be 16-bit universal outputs auto-selectable 0-10 VDC @ 10mA maximum (1k ohm minimum) or 0-20mA @ 550 ohms maximum.
10. Ambient Space Rating : 0 to 158 degrees F and 5 to 95 percent RH.
11. Include support for intelligent room sensor. Display on room sensor to be programmable at controller and include an operating and field service mode. Button functions and display data to be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

- B. BACnet Conformance:
1. As a minimum, support MS/TP BACnet LAN types. They shall communicate directly using this BACnet LAN at 9.6, 19.2, 38.4, 76.8, and 115.2Kbps, as a native BACnet device. Application controllers shall be approved by the BTL as meeting the BACnet Application Specific Controller requirements and support BACnet services necessary to provide the following BACnet BIBBs:
    - a. Data Sharing - DS-RP-B, DS-RPM-B, DS-WP-B, DS-WPM-B.
    - b. Device and Network Management - DM-DDB-B, DM-DOB-B, DM-DCC-B, DM-TS-B, DM-RD-B.
  2. Refer to ANSI/ASHRAE Standard 135, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. Proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data.
  3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types. Proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. Necessary tools shall be supplied for working with proprietary information.
  4. Application Controllers:
    - a. BACnet Protocol Implementation Statements per ANSI/ASHRAE Standard 135.
    - b. Conform to FCC Part 15, Subpart J, Class A.
- C. Custom Programs: Standalone application controllers for, but not limited to, the following application types: Custom Air Handling Units, Boiler Plant and Chiller Plant.
- D. Application Specific Controllers:
1. Support, but not limited to, the following system types to address specific applications: Rooftop Air Handlers, VAV terminal units and Fan Coil Units.
  2. Application Specific Descriptions:
    - a. VAV/CAV Unit Application Controllers:
      - 1) One native BACnet application controller for each VAV box covers objects listed in object list for unit. Interface with building controller via MS/TP LAN using BACnet protocol. Do not use gateways. Include on board CFM flow sensor, inputs, outputs and programmable, self-contained logic program as needed for control of units.
      - 2) Support, but not be limited to, control of the following configurations of VAV boxes to address current requirements described in Execution portion of specification, the operational sequences described in Division 23, and for future expansion:
        - a) Single duct, cooling only with or without reheat.
        - b) Dual duct.
        - c) Fan powered (series or parallel).
      - 3) Support the following types of inputs and outputs:
        - a) Variable Air Volume control outputs.
        - b) Reheat control outputs.
        - c) Air Flow Inputs (maybe calculated from velocity inputs).
        - d) Space temperature inputs.
        - e) Analog space temperature setpoint.
        - f) Binary unoccupied override inputs.
      - 4) Operation modes supported by VAV Terminal Unit Controllers:
        - a) Daily/Weekly schedules.

- b) Occupancy mode.
  - c) Unoccupied mode.
  - d) Temporary override mode.
- b. Fan Coil Unit Controls:
- 1) Support, but limited to operational sequences described in Division 23.
  - 2) Support the following input and output types:
    - a) Modulated heating and cooling control outputs.
    - b) Space temperature inputs.
    - c) Analog space temperature setpoint adjustment inputs.
    - d) Binary unoccupied override inputs.
  - 3) Modes of operation supported by Fan Coil Unit Controllers:
    - a) Daily/weekly schedules.
    - b) Occupancy mode.
    - c) Unoccupied mode.
    - d) Temporary override mode.

**\*\* NOTE TO SPECIFIER \*\*** The following paragraph is only needed for projects where VLD-362 or VLD-362-FF controllers are required. Delete for all other projects.

- c. Touch Screen Communicating Thermostat: BTL approved.
- 1) Meet BACnet Application Specific Controller requirements.
  - 2) Support MS/TP BACnet LAN types. Communicate directly through this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as native BACnet device.
  - 3) BACnet object types supported: Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types.
  - 4) Proprietary Object Types: Thoroughly document and provide as part of submittal data. Supply tools for working with proprietary information.
  - 5) Wall mounted controllers operated in stand-alone mode and under supervisory mode from Building Controller.
- d. Touch screen Communicating Thermostat Hardware:
- 1) 32 Bit processor.
  - 2) Backlit touch screen for user interface. Buttons are not allowed.
  - 3) Three universal inputs, 12-bit resolution, accepts 3K and 10K Type II thermistors, 0-10 VDC, 0-5 VDC, 4-20 mA, and dry contact signals. Inputs may be either analog or digital.
  - 4) Built-in temperature and humidity sensors.
  - 5) Six relay outputs on board.
  - 6) Two analog outputs, 12-bit resolution. Each auto-detecting for 0-10 V or 4-20 mA control signals.
- e. Touch screen Communicating Thermostat hardware:
- 1) Meet requirements of Listed Underwriters Laboratory for Open Energy Management Equipment (PAZX) under UL Standard for Safety 916.
  - 2) Meet requirements of EMC Directive (European CE Mark) EN 60950.
  - 3) Meet requirements for FCC Part 15, Class B.
  - 4) Powered by 24 VAC.

**\*\* NOTE TO SPECIFIER \*\*** The following section (2.7.f) should be deleted for VLD-362-FF only, otherwise leave for VLD-362.

- f. Touch screen communicating thermostat programming shall:
- 1) Program sequences stored on board in Flash Memory.
  - 2) No batteries needed to retain any program.
  - 3) Program sequences executed by controller 10 times per second and capable of multiple PID loops for control of multiple devices.
  - 4) Support internal schedule with real time clock.
  - 5) Support Peer-to-Peer programming.
  - 6) Support lockout of touch screen with a pass code.
  - 7) Programming Controller: Field modifiable over BACnet LANs or remotely with modem interface. Program using same tool as Building Controller and as described in operator's workstation section. Provide programming tools as part of system.

**\*\* NOTE TO SPECIFIER \*\*** The following section (2.8) is only needed for projects where wireless MS/TP is required. You will need to use the AZW-5000 to meet the intent of this section. Delete for all other projects.

#### 2.11 BACNET® TOUCHSCREEN COMMUNICATING THERMOSTAT (BCT) – TC500

##### A. Network Communications:

1. BCT shall be capable of communication via BACnet® IP over Wi-Fi, BACnet® MSTP, Bluetooth.
2. BCT shall be capable of remote cloud-based connectivity via Wi-Fi connection and mobile app to monitor temperature, change set-points, and manage scheduling for up to 20 thermostats
3. Standard BACnet® object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types.
4. BACnet® settings shall be configurable via HMI or via Niagara Wizard.

##### B. BCT hardware shall:

1. Include a 4" dimmable LCD touchscreen display, 480x480 pixels
2. Include two (2) configurable universal input/outputs:
  - a. Proportional inputs may be received as 10K NTC type II, 10K NTC type III, 20K NTC, or 0-10Vdc sensors.
  - b. Digital inputs may be received as dry contact closures, open circuit ( $\geq 100K$  ohms), or closed circuit ( $\leq 100$ ohms).
  - c. Proportional outputs are 0-10Vdc.
3. Include two (2) universal inputs:
  - a. Proportional inputs may be received as 10K NTC type II, 10K NTC type III, 20K NTC, or 0-10Vdc sensors.
  - b. Digital inputs may be received as dry contact closures, open circuit ( $\geq 100K$  ohms), or closed circuit ( $\leq 100$ ohms).
4. Include one (1) digital relay output rated at 1 Amps max at 24VAC
5. Include one (1) aux digital dry contact relay output rated at 1 Amps max at 24VAC/DC
6. Include built-in temperature sensor.
7. Include built-in humidity sensor.
8. Include built-in proximity sensor.
9. Include RS-485 terminals.
10. Comply with the following certificates and standards: CE, FCC, ICES, UL/cUL, RoHs, REACH, California, Title 24, Prop65, EN 60730-1, EN 60730-2-9, EN 301489-1, EN

301489-17, EN 300328, EN 301893, EN 62479, UL60730-1, UL60730-2-9, Title 47 part 15 subpart B, Title 47 part 15subpart C, RSS 210, ICES-003.

11. Be powered by 24 VAC power.

## 2.12 BACNET® TOUCHSCREEN COMMUNICATING FAN COIL THERMOSTAT (FCT) – TC300

A. Fully functional control of 2-Pipe and 4-Pipe Fan Coil Unit applications, RTU applications (1H / 1C), Heat Pump applications (2H / 1C Air & Water Source).

B. FCU Applications

1. 4-Pipe single coil, 4-Pipe dual coil, & 2-Pipe single coil.
2. Floating, modulating, 6-way valves, On/Off valves, Changeover valve (4-pipe).
3. Up to 3-speed fan or variable speed fan.
4. Option for enabling valve output for heating and cooling w/modulating valves.
5. Discharge air temperature control.
6. Discharge air temperature cooling/heating lockout (optional sensor).
7. Onboard humidity sensor with configurable dehumidification and dehumidification w/reheat options (fan coil equipment type).
8. Onboard humidity sensor with configurable dehumidification or humidification (conventional and heat pump equipment type).
9. Auxiliary and peripheral reheat option.
10. Hybrid 2-pipe changeover allowing more rapid transition to support heating or cooling function before chilled water or hot water reaches target threshold.

C. Features

1. Conventional 1 Heat / 1 Cool.
2. Heat pump air/water source 2 Heat / 1 Cool (2nd stage heat is auxiliary).
3. Conventional or heat pumps simple humidification or dehumidification option.
4. Automatic heat/cool changeover with 2°F (1°C) minimum dead band.
5. Real-time Clock with 72-hour retention during power loss.
6. Daily schedule copy feature to multiple days of week.
7. Up to four occupied or standby periods per day.
8. Temporary override for a 0 to 18-hour configurable period, with 3-hour default.
9. 365-day schedule with options for holidays and special events.
10. Programmable temporary setpoint adjustment limit of up to +/-45°F (+/-25°C).
11. Configurable heating and cooling parameters including minimum operating cycle time, throttling range, and cycles per hour.
12. Configurable recovery ramps for heating and cooling.
13. Display or control room temperature in °F or °C.
14. Integration with multiple remote temperature sensors (Microset bus or analog) with configurable weighted averaging (optional).
15. Four levels of user management – installer, admin, basic user, and visitor.
16. Remote occupancy sensor input for auto Standby/Occupied mode regulation.
17. Auto sleep display to reduce energy consumption without user interaction after time-out.
18. Configurable drain pan sensor or shutdown input configurable for thermostat shutdown mode of operation.
19. Complies with FCU High-Performance Sequences of Operation ASHRAE Guideline 36-2021, Sec. 5.22.
20. 5-year warranty.

- D. Network Communications:
  - 1. FCT shall be capable of communication via BACnet® MSTP or Modbus RTU, and Microset.
  - 2. FCT shall be capable of remote cloud-based connectivity via Wi-Fi connection and mobile app to monitor temperature, change set-points, and manage scheduling for up to 20 thermostats.
  - 3. Standard BACnet® object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types.
  - 4. BACnet® system scheduling and holiday configuration
  - 5. BACnet® settings shall be configurable via HMI or via Niagara Wizard.
- E. FCT hardware shall:
  - 1. Include a 2.4" Diagonal capacitive color touch screen LCD display (320x240 pixel).
  - 2. Two color LED indicator ring to show the operational status (heat, cool).
  - 3. System status screen showing device information, live status, and sensor readings.
  - 4. Include three (3) configurable universal input/outputs:
    - a. Proportional inputs may be received as 10K NTC type II, 10K NTC type III, 20K NTC, or 0-10Vdc sensors.
    - b. Digital inputs may be received as dry contact closures, open circuit ( $\geq 100K$  ohms), or closed circuit ( $\leq 100$ ohms).
    - c. Proportional outputs are 0-10Vdc.
  - 5. Include two (2) universal inputs:
    - a. Proportional inputs may be received as 10K NTC type II, 10K NTC type III, 20K NTC, or 0-10Vdc sensors.
    - b. Digital inputs may be received as dry contact closures, open circuit ( $\geq 100K$  ohms), or closed circuit ( $\leq 100$ ohms).
  - 6. Include three (3) configurable relay outputs rated at 1 Amps max at 24VAC.
  - 7. Include built-in temperature and humidity sensor.
  - 8. Include built-in proximity sensor.
  - 9. Include RS-485 terminals.
  - 10. Comply with the following certificates and standards: CE, FCC, ICES, UL/cUL, RoHs, REACH, California, Title 24, Prop65, EN 60730-1, EN 60730-2-9, EN 301489-1, EN 301489-17, EN 300328, EN 301893, EN 62479, UL60730-1, UL60730-2-9, Title 47 part 15 subpart B, Title 47 part 15 subpart C, RSS 210, ICES-003.
  - 11. 20-30 VAC operational voltage range.

## 2.13 WIRELESS MS/TP TRANSCEIVER

- A. General Requirements:
  - 1. Wireless MS/TP Transceivers are to support Multiple BACnet Application Specific Controllers (B-ASC) to a Transceiver MS/TP trunk, and multi-transceiver mesh wireless network topology.
- B. BACnet Conformance:
  - 1. Wireless MS/TP Transceiver: Meet BACnet Addendum q, ANSI/ASHRAE 135.
    - a. Support MS/TP BACnet LAN types. Communicate directly BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a B-ASC BACnet device.
  - 2. Object Types: Analog Value, Binary Value, Device, File, and Program Object Types.
  - 3. Proprietary Object Types: Thoroughly documented and provided with submittal data. Supply tools for working with proprietary information.
- C. Wireless MS/TP Transceiver hardware shall:

1. Include a 32 Bit processor.
  2. Include two selectable internal antennae with perpendicular orientation.
  3. Support external antenna using industry standard SMA connector type.
  4. Support connection to 2.4 GHz (IEEE Std 802.15.4-2003 compliant) Wireless Wall Sensors (Battery powered).
  5. Meet the requirements of Listed Underwriters Laboratory for Open Energy Management Equipment (PAZX) under the UL Standard for Safety 916.
  6. Meet the requirements of EMC Directive (European CE Mark) EN 60950.
  7. Meet the requirements for FCC Part 15, Class B.
  8. Meet the requirements for EU Wireless: EN300328-1 2.4 GHz Spread Spectrum, EN301489-1:2000 Standard.
  9. Be powered by 24 VAC power.
- D. Wireless MS/TP Transceiver firmware shall:
1. Configuration and point data shall be stored on board transceiver in Flash Memory.
  2. No batteries shall be needed to retain configuration data.
  3. Configuration of Wireless MS/TP Transceiver shall be completely modifiable in the field over installed BACnet LANs or remotely using modem interface.
  4. Wireless MS/TP communication encrypted to 128 bit AES encryption standard.
- E. Wireless wall sensors general requirements.
1. Wireless wall sensors shall be supported by the Wireless MS/TP Transceiver and support up to Fifty (50) wireless wall sensors simultaneously.
  2. Wireless wall sensors shall operate in the 2.4 GHz (IEEE Std 802.15.4-2003 compliant) radio frequency
  3. Support temperature and humidity, setpoint and after-hours override wireless wall sensor types.
  4. Wireless communication shall be encrypted to 128 bit AES encryption standard.
  5. Shall use 2.4 GHz radio frequency (IEEE Std 802.15.4-2003 compliant).
  6. A mechanical means to lock wall sensor to base to prevent theft and vandalism.
- F. Wireless Wall Sensor: Solid-state sensors packaged in aesthetically pleasing enclosure.
1. Override function, warmer/cooler dial for set point adjustment. Store override time in controller and be adjustable on a zone-by-zone basis. Adjustment range for warmer/cooler lever to also be stored in EEPROM on controller.
  2. Temperature: Plus or minus 0.5 degree Celsius from 12 to 30 degrees Celsius.
  3. Humidity Sensor: Accuracy: Plus To minus 3 percent RH from 11 to 89 percent RH.
  4. Communications Range in open air: Meet or exceed 300 ft. Strength of signal must be indicated at wireless sensor to aid in placement and trouble shooting.
  5. Receiver: A wireless communications received light indicating proper communication.
  6. Sensor/Receiver: Paired in addressable mean to facilitate easy replacement and reassignment.
  7. Run on two AA Lithium batteries; battery life of 5 years. Low battery power to be indicated on unit via LED and readable as a BACnet Object.

#### 2.14 ELECTRONIC CONTROL DEVICES

- A. Temperature Sensors (Microset 4): Solid-state electronic, interchangeable with housing appropriate for application. Wall sensors: Install as indicated on drawings. Mount 48 inches (1219 mm) above finished floor. Duct sensors: Install so sensing element is in the main air stream. Immersion sensors: Install in wells. Immersion wells to be filled with thermal compound before installation of immersion sensors. Outside air sensors: Install away from exhaust or relief vents, not in an outside air intake, and in a shaded location.

**\*\* NOTE TO SPECIFIER \*\* Intelligent room sensor with touchscreen is optional if specifying Microset 4 with MS/TP or CO2, but not both. Delete if not required.**

- B. Intelligent Room Sensor with Touchscreen:
1. General Requirements:
    - a. Backlit touchscreen LCD digital display.
    - b. Temperature sensor.
    - c. Humidity sensor.
    - d. Programmable Status Light indicator.
    - e. CO2 sensor or BACnet MS/TP communication up to 115.2 kbps.
    - f. Interact with smart sensor using a touchscreen, with no buttons allowed.
    - g. Tamper proof installation requiring tools to be removed from the wall.
    - h. Touchscreen: Surface hardness of Mohs 7 or greater preventing scratching.
    - i. Controller: Function as room control unit, and allow occupant to raise and lower setpoint, and activate terminal unit for override use-all within limits as programmed by building operator.
  2. Space Temperature Sensor: Uni-Curve Type II thermistor. Accuracy: Plus or minus 0.36 degrees F (0.3 degrees C) at calibration point over range of 32 to 158 degrees F.
  3. Humidity Sensor: Accuracy: Plus or minus 3 percent from 10 to 90 percent relative humidity (RH) or better, non-condensing.
  4. Status Light indicator: A minimum of 4 colors, blue, red, amber, and green. Will cast a glow onto wall below sensor to be used as visual indicator to occupants of system condition. Color and on/off state of Status Light indicator to be fully programmable.
  5. CO2 Sensor: Accuracy: Plus or minus 30 ppm over range of 0 to 5000 ppm.
    - a. Automatic Baseline Correction maintains calibration. No manual calibration.
  6. Display Content:
    - a. Intelligent room sensor:
      - 1) Simultaneously display room setpoint, room temperature, and outside temperature at each controller.
      - 2) Ability to add or remove time-of-day, room humidity, and indoor air temperature to customize view for customer. Must have the capability to show temperatures in degrees Fahrenheit or degrees Celsius.
      - 3) Display status of a lighting zone and control on/off state of zone from touchscreen using a tenant-accessible display page.
      - 4) Display status of window zone (e.g., blinds) and control on/off state of zone from touchscreen using a tenant-accessible display page.
    - b. A communication loss or improper communications wiring to be displayed on the LCD screen to aid in trouble shooting.
    - c. Firmware version information to be displayable on the LCD screen.
    - d. Cleaning mode: Allow cleaning of touchscreen.
  7. After Hours Override:
    - a. Be set and viewed in 30-minute increments.
    - b. Override countdown: Automatic, but can be reset to zero by from the sensor.
    - c. The remaining time shall be displayed.
    - d. Display "OFF" in unoccupied mode unless a function button is pressed.
  8. Configuration Modes:
    - a. Intelligent Room Sensor: Service technician access to hidden functions for advanced system configuration. Functionality accessed-protected with a

- configurable PIN number.
- b. Field Service Mode shall allow access to common parameters as dictated by application's sequence of operations. Parameters shall be viewed and set from intelligent room sensor with no computer or other field service tool needed.
  - c. If the intelligent room sensor is connected to VAV controller, Balance Mode shall allow a VAV box to be balanced and air flow parameters viewed. The balancing parameters shall be viewed and set from the intelligent room sensor with no computer or other field service tool needed.
9. Conformance: Intelligent Room Sensor to be in compliance of the following:
- a. UL Standard for Safety 916.
  - b. FCC Part 15.107 and 109, Class B, CFR47-15.
  - c. EMC Directive 89/336/EEC (European CE Mark).

**\*\* NOTE TO SPECIFIER \*\*** The following section (2.11) is only needed for projects where a BACnet capable display is required. You will need to use the AlerView to meet the intent of this section. Delete for all other projects.

## 2.15 OPERATOR DISPLAY (AlerView)

- A. General Requirements:
1. 7-inch touchscreen display shall support in-wall flush on-wall surface tabletop, and panel door mounting.
  2. Display shall be 7-inch IPS with a resolution of 104x600 and a brightness of 350nit; touch panel shall be capacitive screen with five points touch.
  3. Microprocessor shall be ARM Cortex A7 dual core running at 1.2 GHz.
  4. Memory shall include 2GB RAM and 4GB Flash
  5. Power options shall include 110-24VAC via AC adapter, 9-30VDC direct, and PoE IEEE 802.3af (15.4W, 48V)
  6. Communications shall support Ethernet 10/100 and EIA-485 over TSP with manual settings of 9.6, 19.2, 38.4, 76.8, and 115.2 kbps.
  7. Network protocols supported shall include BACnet/IP, BACnet/MSTP, DHCP, and ICMP Type 8 and Type 0.
  8. IP addressing shall be selectable between Automatic (DHCP) and Manual (static).
  9. BACnet/IP addressing shall include setting of the Device Object properties (instance, name, description, location); UDP Port; and BBMD IP address and UDP port for registering as a foreign device.
  10. BACnet/MSTP addressing shall include setting of the MAC address and baud rate.
- B. Display Configuration and Capabilities
1. Display shall provide the following user configurable content.
    - a. Home Screen with background image in PNG format @ 1024x600mm, logo image in PNG format @ 48x48mm, and up to six featured point tiles.
    - b. Device Tiles in the following formats: single (1 featured point), tall (4 featured points), quad (8 featured points), and full screen (12 featured points).
    - c. Point Tile Templates shall provide for the display of up to six data point tiles per screen. Multiple screens shall be supported, with navigation between screens by user swipe left and right as well as by jump-to-screen via screen designator.
  2. BACnet Point Objects
    - a. The following BACnet point objects shall be supported: analog input, analog output, analog value, binary input, binary output, and binary value.
    - b. BACnet point object properties supported shall include present value and priority array index.

3. Point Properties
  - a. For each point the following properties shall be provided: Tile; Object Type; Object Instance; Read Only; Access Level; Write Priority; Decimal Display; Binary Active text; Binary Inactive text; Relinquish text; Engineering Unit.
4. User Configurations
  - a. Support for a maximum of 999 users shall be provided.
  - b. Each user shall be configured with the following: unique user ID, name, access level.
  - c. Ten levels of user access shall be provided.
  - d. Each user shall be provided with private password PIN
  - e. User activity shall be logged with date/time stamp for the following activities: logging on/off, changing a point value with old value/new value, change of configuration, and updating display firmware.
  - f. Admin User shall have access to the settings menu for management of users and device configuration.

## 2.16 INTERCONNECTING WIRE AND CABLE

**\*\* NOTE TO SPECIFIER \*\*** Insert paragraphs as required; sample requirements follow.

- A. Wiring regardless of service or voltage will comply with Contract Document Division 16 Project Electrical System Specifications, the National Electric Code (NEC), and any/all applicable local codes and/or Authorities Having Jurisdiction (AHJ).
- B. Where required, wiring, regardless of service or voltage, to be in conduit per Division 16 and routed parallel to or at right angles with the structure. Properly support every 6 ft (1829 mm).
- C. Where permitted by local guides, NEC and AHJ; use plenum-rated control cabling where final application will be concealed but accessible. Where plenum-rated cable is allowed, route parallel to or at right angles with the structure. Support every 6 ft (1829 mm).
- D. The BAS Wiring:
  1. 24 VAC Power: Red/Black jacketed conductors; black jacketed sheath over the pair.
  2. Input/Output – White/Black jacketed conductors; white jacketed sheath over the pair.
  3. Communication: White/Black jacketed conductors; blue jacketed sheath over the pair.

## 2.17 BAS IP NETWORK INFRASTRUCTURE – OPERATIONAL TECHNOLOGY NETWORK

**\*\* NOTE TO SPECIFIER \*\*** Insert paragraphs as required; sample requirements follow.

### PART 1 – GENERAL

#### 1.1 WORK REQUIRED BY CONTRACT DOCUMENTS

- A. In general, the Operational Technology Network (OTN) shall be provided, installed, programmed and commissioned by the Master Systems Integrator (MSI). Refer to drawing M-??? for system architecture/topology.
- B. The MSI shall furnish and install a separate OTN network that is optimized for the needs and safety of Operational Technology (OT) devices, services, and building technologies ie. Security, Lighting Control, Elevators, Fire Alarm and Building Automation. The OTN shall be Fiber Ethernet based.
- C. The OTN shall be an intelligent network that presents network information in the context of automation equipment. The solution provided shall be designed to be easily scalable and repeatable so it can be easily deployed to a wide variety of building technology applications.
- D. The OTN is designed for standalone or networked IP operation with all the required software and hardware to ensure the building systems operation. Outside network connections should only be through the Firewall supplied with the operational network platform firewall.
- E. The OTN Software shall include a web-based Network Management Tool. The OTN Hardware shall include all Fiber Switches, Fiber to Copper Switches, and all Fiber and Ethernet cabling and associated wiring devices.

- F. The MSI shall supply the data from all connected systems to the Owner in a graphical format. The graphics shall be web based and work on all devices capable of running up to date versions of Google Chrome, Safari, Mozilla and or Internet Explorer.

## 1.2 REFERENCED STANDARDS

The structured cabling system installation shall comply with the latest edition of all applicable codes, standards, and regulations including, but not limited to:

1. ANSI/TIA/EIA-568 Commercial Building Telecommunications Wiring Standard
2. ANSI/TIA/EIA-569 Commercial Building Standard for Telecommunications Pathways & Spaces
3. ANSI/TIA/EIA-606-A Administration Standard for Commercial Telecommunications Infrastructure
4. ANSI J-STD-607-A Commercial Building Grounding & Bonding Requirements for Telecommunications
5. NFPA-70 National Electric Code (NEC)
6. NFPA 780 Standard for Installation of Lightning Protection Systems
7. NFPA 101 - Life Safety Code
8. American Society of Testing Material (ASTM)
9. Federal Communications Commission (FCC)
10. Institute of Electrical & Electronics Engineers (IEEE)
11. International Standards Organization (ISO)
12. Occupational Safety & Health Administration (OSHA)
13. Underwriters Laboratories (UL)
14. State and local codes

## 1.3 SYSTEM DESCRIPTION

The MSI shall provide a turnkey installation of all passive elements in the OT Network, including hardware, software, switches, riser cable, patch panels, termination blocks, equipment racks, wire management, ladder rack, labeling, and connectors.

The OTN shall be supplied with a software network management tool on premise and hosted within its own hardware.

The OTN shall be protected by its own Uninterruptable Power Supply (UPS).

1. There shall be a single login to view and manage the entire networking system.
2. The entire system shall be managed via single-management IP address.
3. The user interface shall be web browser based.
4. The user interface shall be locally hosted on the networking equipment.
5. The user interface shall be in graphical format.
6. The user interface shall support all required operations via point-and-click interaction.
7. The user interface shall be supported on a tablet or smartphone.
8. The user interface shall provide configuration of all items as per *Table A: Configuration Settings* below.
9. The graphical user interface (GUI) shall support bulk configuration of all items indicated in *Table A: Configuration Settings* below.
10. The GUI shall display the manufacturer name of all connected devices.
11. The GUI shall graphically display all status information as per *Table B: Status Information* below.
12. The system shall alert the user either graphically or via email for all items as per *Table C: Alarms* below.

13. The user shall be able to perform a PoE reset for any individual device in the system with a single click from the GUI.
14. The system shall maintain historical information for all data indicated in *Table B: Status Information* below.
15. The tables in the GUI shall be sortable and filterable based on relevant data, including but not limited to:
  - a. Bandwidth
  - b. PoE consumption
  - c. Text description
  - d. VLAN
  - e. Connection status
16. The system shall provide a backup and restore mechanism in a user editable format i.e., CSV.
17. The system shall support bulk firmware upgrades for all edge switches in one operation.
18. The system shall allow system-wide auto-creation of a VLAN simply by specifying one or more ports to be on that VLAN, and automatically ensure that traffic passes between the selected ports. There must not be any restriction on port location.

G. Redundancy

1. The networking system shall support passive ring redundancy for inter-switch connectivity (trunk) to protect from fiber cuts and/or breaks.
2. The networking system shall have redundant core switches and support automatic failover, to protect from core switch failures.
3. The networking system shall support Spanning Tree Protocol (STP) to be used in active redundant rings for dual-port IP based devices.
4. The networking system shall support in-app and email notifications upon state changes (failover) of:
  - a. Passive rings
  - b. Redundant core switches
  - c. Active rings controlled by STP
5. The networking system shall provide a Graphical User Interface with clear indication of the following:
  - a. Active and Protect ports in passive ring
  - b. State of STP ports (blocking, forwarding)

Table A: Configuration Settings (read/write)

Item	Setting	Location
PoE	Enable/Disable	Per Port
VLAN	Access/Trunk/Local	Per Port
VLAN	ID	Per Port
PoE	Weekly Schedule	Per Port
Port Status	Enable/Disable	Per Port
Port Label	Text Description	Per Port
Switch Label	Text Description	Per Switch
Switch Status	Enable/Disable	Per Switch
Port Security	MAC Filter	Per Port
System Name	Text Description	Per System
System Details	Text Description	Per System

Table B: Status Information (read only)

Item	Information	Location
Link Status	Up/Down and Speed	Per Port
PoE	Power Consumption	Per port
PoE	Power Budget (Used/Available)	Per Switch
Connected Device	Manufacturer Name	Per Port
Connected Device	MAC Address	Per Port
Traffic	Upstream Bandwidth	Per Port
Traffic	Downstream Bandwidth	Per Port
Traffic	Upstream Bandwidth	Per Switch
Traffic	Downstream Bandwidth	Per Switch
Traffic	Upstream Bandwidth	Entire System
Traffic	Downstream Bandwidth	Entire System

Table C: Alarms

Item	Information	Location	Threshold
PoE	Power Consumption	Per port	User configurable
PoE	Power Budget (Used/Available)	Per switch	Fixed warning levels
Connected Device	Manufacturer Name	Per Port	Notification on change
Connected Device	MAC Address	Per Port	Notification on change
Traffic	Upstream Bandwidth	Per Port	User-Configurable
Traffic	Downstream Bandwidth	Per Port	User-Configurable
Traffic	Upstream Bandwidth	Per Switch	User-Configurable
Traffic	Downstream Bandwidth	Per Switch	User-Configurable
Traffic	Upstream Bandwidth	Entire System	Fixed warning levels
Traffic	Downstream Bandwidth	Entire System	Fixed warning levels

## Part 2 – Products

### 2.1 SMART AGGREGATION SWITCH (Front End Switch):

The Smart Aggregation Switch shall serve as the Front End for the network. This switch shall allow the entire network to be centrally managed and monitored in real time from a graphical user interface that is web-hosted directly on the switch. The switch shall have LED status indicators displaying Alarms, Power, Link and Redundancy. Unit shall have the ability to be rack or wall mounted and supplied with brackets if wall mounted. The switch shall support all protocols used in Building Automation and Security. EPON Standard shall be IEEE 802.3ah GEPON, 1 Gbps bidirectional, 1310/1490- nm. Shall support single-strand, single-mode Optical Fiber OS1/OS2 9/125 μm, up to 8 km reach. Shall be able to handle traffic from Ethernet, TCP/IP or UDP/IP, BACnet/Ethernet, BACnet/IP. Switch shall have a minimum 3 year warranty.

### 2.2 EDGE SWITCHES (Fiber to Ethernet and Fiber to Fiber):

Edge switches shall be selected based on specific project topology. Edge switches shall be designed to allow all ports from every switch to be monitored and managed from the front-end aggregation switch and graphical user interface. PoE specification shall be 802.3at PoE+, 30W available on every port (also 802.3af, 15W per port). Switches shall have the ability to be mounted via, DIN, Wall, or Rack as needed. EPON Standard shall be IEEE 802.3ah GEPON, 1 Gbps bidirectional,

1310/1490- nm. Shall support single-strand, single-mode Optical Fiber OS1/OS2 9/125  $\mu\text{m}$ . Connector shall be Simplex SC/UPC Female Connector. Shall be able to handle traffic from Ethernet, TCP/IP or UDP/IP, BACnet/Ethernet, BACnet/IP. Switch shall have a minimum 3 year warranty.

### 2.3 FIBER OPTIC CABLING

- A. Fiber optic cabling shall be provided between the OTN switches, splitters and the OTN Server location.
- B. Fiber optic cabling shall utilize aluminum interlocking armor covering an internal plenum jacket.
- C. Indoor/outdoor fiber optic cable shall meet or exceed the performance criteria found in TIA/EIA 568C.3 Optical Fiber Cabling Components.
- D. Fiber optic cable shall be UL  $\square$  and c (UL  $\square$ ) Listed.

### 2.4 FIBER SPECIFICATION

- A. Single-mode fiber (SMF) 9/125
  - 1. Either OS1 or OS2 grade fiber is acceptable.
  - 2. The fiber must have an internal diameter of 9 microns, and an external diameter of 125 microns.
  - 3. Fiber must be terminated with SC/UPC connectors.
  - 4. Only a single strand of fiber is required for each fiber run. Pairs are only required if product uses separate wavelengths of light to enable bidirectional traffic on a single fiber.
  - 5. Insertion losses must be less than 0.3 dB / termination plus 1.0 dB / km.

### 2.5 TERMINATION TECHNIQUES

It is important to have high quality terminations to ensure that the planned OTN Budget is not broken. The following recommendations for the following termination strategies, in order:

- 1. Pre-terminated fibers ordered and manufactured to appropriate lengths. (Best)
  - a) These can be ordered with pull-eyes for pulling through conduit.
- 2. On-site fusion splicing with pre-terminated SC/UPC pigtails. (Good)
- 3. On-site termination with SC/UPC connectors. (Quality can vary)

### 2.6 CABLE TYPES & INSTALLATION CONSIDERATIONS

- A. The type of cabling does not matter. Follow manufacturer's recommendations based on a single strand of fiber.
- B. Based on the topology & environment, the type of fiber cabling desired may vary significantly, for instance:
  - 1. Single Strand 3mm Jacket for simple runs - In ceiling, cable tray, floor-to-floor conduit
  - 2. 6 or 12 strand cable with MPO connectors / breakout panel for longer runs or complex designs
- C. Heavy Jacket 24 strand cable for outdoor or trench scenarios.
- D. When using a multi-strand cable, it is not necessary to terminate all strands if they are not needed for the design.
- E. Patch Panels are not required, but they may help with fiber organization and cable management for complex designs.
- F. Splitters shall be ordered with long or custom fiber lead lengths. In some cases, intermediate fiber may not be required. Product shall also provide indoor patch cables in 1,3,5, and 20-meter lengths.

G. Ensure that the fiber installer has experience working with Single mode Fiber.

## 2.7 BEST PRACTICES

- A. All fibers should be clearly labelled and documented, including damaged or unterminated strands. For detailed recommendations consult ANSI/TIA/EIA-606.
- B. All fibers should be tested by the best means available: Tier 1 insertion loss testing or Tier 2 OTDR testing at 1310 and 1550 nm with detailed reporting.

Approved vendors: Optigo Networks or approved equal

## 2.18 ELECTRONIC ACTUATORS AND VALVES

**\*\* NOTE TO SPECIFIER \*\* Insert paragraphs as required; sample requirements follow.**

- A. Quality Assurance for Actuators and Valves:
  - 1. UL Listed Standard 873 and C.S.A. Class 4813 02 certified.
  - 2. NEMA 2 rated enclosures for inside mounting. Weather shield for outside mounting.
  - 3. Five-year manufacturer's warranty. Two-year unconditional and three-year product defect from date of installation.
- B. Execution Details for Actuators and Valves:
  - 1. Freeze-stat and "Hard Wire" interlock to disconnect mechanical spring return actuator power circuit; fail-safe operation. Do not use control signals to drive actuators closed.
  - 2. DDC analog output points to have an actuator feedback signal, independent of control signal, wired and terminated in control panel for true position information and troubleshooting. Or wire the actuator feedback signal to DDC as an analog input for true actuator position status.
  - 3. VAV box damper actuation to be floating type or analog (2 to 10 VDC, 4 to 20 mA).
  - 4. Booster-heat valve actuation to be floating type or analog (2 to 10 VDC, 4 to 20 ma).
  - 5. Primary valve control shall be analog (2 to 10 VDC, 4 to 20 mA).
- C. Actuators for damper and control valves 0.5 to 6 inches (13 to 152 mm). Electric unless otherwise specified. Provide as follows:
  - 1. UL Listed Standard 873 and Canadian Standards association Class 481302.
  - 2. Enclosures: NEMA 2 rated for inside mounting. Weather shield for mounting outside.
  - 3. Five-year manufacturer's warranty. Two-year unconditional and Three year product defect from date of installation.
  - 4. Mechanical Spring: When specified. Do not use non-mechanical fail-safes.
  - 5. Position indicator device installed visible to exposed side of actuator. For damper short shaft mounting, provide a separate indicator to exposed side of actuator.
  - 6. Overload Protection: Protection against burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit to insure actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate actuator at end of rotation are acceptable for butterfly valve actuators.
  - 7. A Pushbutton gearbox release shall be provided for non-spring actuators.
  - 8. Modulating actuators shall be 24 VAC and consume 16 VA power or less.
  - 9. Conduit connectors are required when specified and when code requires it.
- D. Damper Actuators:
  - 1. Outside air and exhaust air damper actuators: Mechanical spring return. Do not use non-mechanical forms of fail-safes. Mounting arrangement and spring return feature to permit normally open or normally closed positions of damper.
  - 2. Economizer Actuators: Analog control 2-10 VDC. Floating control is not acceptable.
  - 3. Electric damper actuators (and VAV box actuators): Direct shaft-mount. Use V-bolt and toothed V-clamp for positive gripping.
  - 4. One electronic actuator direct shaft-mounted per damper section. No connecting rods

or jackshafts. Small outside and return economizer dampers may be mechanically linked if one actuator has sufficient torque to drive both horizontal drive shafts.

5. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft-mounted per damper section. (See below execution section for more installation details.)
- E. Valve Actuators: 0.5 to 6 inches (13 to 152 mm).
1. Mechanical spring on actuators for pre-heat coil and actuators for AHU heating or cooling coil for outside mounted units. Fail-safe flow function: Normal Open or Normal Closed. Capacitors or non-mechanical forms of fail-safe are not acceptable.
  2. Zone service actuators: Non-spring return unless otherwise specified.
  3. Provide minimum torque required for proper valve close-off for required application.
  4. Control valves actuators: Attached 3-foot cable for easy installation to a junction box.
  5. Override handle and gearbox release for non-spring return valve actuators.
- F. Control Dampers. NOTE: Visit <https://honeywelldampers.com> for selection tool.

**\*\* NOTE TO SPECIFIER \*\* Pick either BAS or sheet metal contractor.**

1. Furnish and size automatic control dampers unless provided with packaged equipment. Install dampers if not with packaged equipment.
  2. Modulating Service: Opposed blade type. Arrange for normally open or closed operation. Size damper so when wide open, pressure drop is a sufficient amount of its close-off pressure drop for effective throttling.
  3. Two-position or open-close control: Parallel blade type. Arrange for normally open or closed operation as required.
  4. Alignment plates for multi-section dampers.
  5. Linkage Hardware: Aluminum or corrosion-resistant zinc and nickel-plated steel.
    - a. Bearing support bracket and drive blade pin extension for each damper section. Permanent indication of blade position by scratching or marking visible end of drive blade pin extension.
    - b. Drive Pin: May be round if V-bolt and toothed V-clamp is used for positive gripping. For single bolt or set-screw type fastening, mill flat round damper pin to avoid slippage.
- G. Control Valves: Size varies based on valve type.
1. Furnish specified motorized control valves, actuators, and control wiring to actuators. Equal percentage control characteristic for water coil control valves. Linear characteristic is acceptable for 3-way valves 2.5 inches (64 mm) and above.
  2. Characterized Control Valves: For hydronic heating or cooling and small to medium AHU water-coil applications, and Unitary equipment and closed loop application. Actuators: Non-spring return for terminal unit coil control unless otherwise noted. If coil is exposed to outside air stream, see plans for spring return requirement.
    - a. Leakage: ANSI Class IV seat leakage. Differential wrt Close-off: Differential close-off pressure shall be at least 40 psid for 3-way valves and 100 psid for 2-way valves
    - b. Valves 0.5 to 2 inches (13 to 51 mm): Forged brass body. NPT screw type connections. Valve sizes varies from 0.5" to 3" with threaded 2way & 0.5" to 2.5" with 3way.
    - c. Valves threaded connection 0.5 to 3 inches (13 to 32 mm): ANSI Class 600 working pressure.
    - d. Operating Temperature Range: 0 to 250 degrees F.
    - e. Stainless steel ball/Nickel-plated brass ball and stem furnished on modulating valves.

- f. Seats to be fiberglass reinforced Teflon.
  - g. Two- and three-way valves: Equal percentage control port. Full stem rotation is required for maximum flow to insure stable BTU control of coil.
  - h. Three-way valve to be applicable for both mixing and diverting.
  - i. Characterizing Disc: TEFZEL; keyed and secured by retaining ring.
  - j. Stem: Blow-out proof. Stem Packing: 2 lubricated O-rings for on-off or modulating service and to require no maintenance.
  - k. The valves shall have an ISO type, 4-bolt flange for mounting actuator in any orientation parallel or perpendicular to the pipe All valves and actuators shall be manufactured under ISO 9001 International Quality Control Standards
  - l. Actuated valves shall be capable of closing off against their maximum operating differential pressure. Seat leakage when closed shall be ANSI/ASME Class IV, minimum.
  - m. Actuators shall be direct coupled rotary type requiring neither crank-arm nor linkage and direct mount to the valve actuator bracket. The bracket shall provide for up to 2 inches (50mm) of pipe insulation and provide a torque of a least 27 lb-in for valves up to 1 ¼ inches and a torque of at least 44 lb-in for valves up to 3 inches.
3. Globe valves: 0.5 - 2 inches threaded (13 mm - 51 mm) shall be used for steam control (100psi pressure), water, and glycol solutions (up to 50 percent concentration)
- a. Valves shall be red brass body, NPT screw type, and shall be rated for ANSI Body Class 150
  - b. Valves 0.5 inches (13 mm) (DN15) through 2 inches (51 mm) (DN50) with seat leakage rate ( $\leq 0.05$  percent of CV) with Maximum Water Close off: 230 psid (also depends on actuator torque).
  - c. The operating temperature range shall be 36-337 degrees F.
  - d. Threaded valve Packing: Spring-loaded, carbon fiber reinforced PTFE V rings
  - e. Two-way & Three way mixing valves shall have an equal percentage control port.
  - f. Three-way valves shall have a linear control and bypass port.
  - g. Mixing and diverting valves must be installed specific to the valve design.
4. Globe Valve: 2.5 to 6 inches (64 to 152 mm) (DN65 to DN50)
- a. Body: ANSI Class 125 and Class 250 flanged cast iron bodies. Differential pressure of 175 psi, ANSI Class IV leakage on pressure-balanced models, 0.05% of Cv (ANSI Class III) for 2way, <0.1% of Cv ANSI Class III for 3way.
  - b. Flow Type, 2-Way, 3-Way Mixing: Equal percentage. Flow Type 3-Way Diverting: Linear.
  - c. Mixing and Diverting Valves: Installed specific to valve design.
5. Butterfly Resilient Seat Valves: Sized for modulating service at 60 to 70 degree stem rotation.
- a. Isolation valves to be line-size. Design velocity: Less than 12 ft (3658 mm) per second when used with standard EPDM seats.
  - b. Body is Polyester coated ductile iron
  - c. Disc is 304 Stainless steel
  - d. Seat is Reinforced EPDM.
  - e. Cold working pressure 232psi, body pressure rating consistent with ASME/ANSI Class 125, Media temp -22 °F to 250 °F.
  - f. Flange is ASME/ANSI class 125/150 flanges
  - g. Maximum Differential Pressure: 200 psi for 2 inches to 12 inches, 150psi 14 inches to 24 inches
6. Butterfly Valve Industrial Actuators:
- a. CE Compliant, Underwriters Laboratories, Inc - C/US Listed up to 12 in. Assemblies, Canadian Standards Association - C/US Certified, 14 in. and larger

- assemblies for 2way resilient and CE - Compliant Underwriters Laboratories, Inc C/US UL873 for 3way resilient butterfly valve. Enclosure: NEMA 2 & NEMA 4 (weatherproof). CE - Compliant Underwriters Laboratories, Inc C/US Listed, up to 6 in. assemblies Canadian Standards Association C/US Certified, 8 in. and larger assemblies for High performance 2way, CE - Compliant Underwriters Laboratories, Inc C/US Listed, up to 4 in. assemblies Canadian Standards Association C/US Certified, 5 in. and larger assemblies for 3way High performance Valves.
- b. Continuous Duty Motor: Fractional horsepower; permanent split capacitor type designed to operate on a 120 VAC, 1 pH, 60 Hz supply. Provide two adjustable cam-actuated end travel limit switches controlling travel direction. Self-resetting thermal switch imbedded in motor for overload protection.
  - c. Two adjustable SPDT cam-actuated auxiliary switches, rated at 250 VAC for indication of open and closed position.
  - d. Heater to minimize condensation within actuator housing.
  - e. Hand crank: For manual override of actuator to operate valve during power failure or system malfunction. Permanently attached to actuator. When in manual operation electrical power to actuator must be permanently interrupted. Hand wheel will not rotate while actuator is electrically driven.
  - f. The actuator shall be analog, floating, or two position as called out in the control sequence of operation. Analog valves shall be positive positioning, and respond to a 2 to 10 VDC, 4 to 20 mA, or adjustable signal as required. Analog actuators shall have a digital control card allowing any voltage input for control and any DC voltage feedback signal for position indication.
7. Performance Verification Test:
- a. Control loops Cause productive actuation with each actuator movement. Actuators to modulate at rate that is stable and responsive. Actuator movement is not occur before effects of previous movement have affected sensor.
  - b. Actuator to be capable of signaling a trouble alarm when actuator Stop-Go Ratio exceeds 30 percent.
  - c. Actuator mounting for damper and valve arrangements; comply to the following:
  - d. Damper actuators: Shall not be installed in the air stream
  - e. A weather shield shall be used if actuators are located outside. For damper actuators, use clear plastic enclosure.
  - f. Damper or valve actuator ambient temperature shall not exceed 122 degrees F through any combination of medium temperature or surrounding air. Appropriate air gaps, thermal isolation washers or spacers, standoff legs, or insulation shall be provided as necessary.
8. Actuator cords or conduit shall incorporate a drip leg if condensation is possible. Water shall not be allowed to contact actuator or internal parts. Location of conduits in temperatures dropping below dew point shall be avoided to prevent water from condensing in conduit and running into actuator.
9. Damper mounting arrangements: Comply to the following:
- a. Ventilation Subcontractor: Furnish/install damper channel supports and sheet metal collars.
  - b. No jack shafting of damper sections shall be allowed.
  - c. Multi-section dampers shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per section.
10. Size damper sections based on actuator manufacturer's specific recommendations for face velocity, differential pressure and damper type. In general:
- a. Damper section shall not exceed 24 ft-sq. with face velocity over 1500 FPM.
  - b. Damper section shall not exceed 18 ft-sq. with face velocity over 2500 FPM.

- c. Damper section shall not exceed 13 ft-sq. with face velocity over 3000 FPM.
- 11. Multiple section dampers of two or more shall be arranged to allow actuators to be direct shaft mounted on the outside of the duct.
- 12. Multiple section dampers of three or more sections wide to be arranged with a 3-sided vertical channel (WxD) 8 x 6 inches (203 x 152 mm) within duct or fan housing and between adjacent damper sections. Vertical channel to be anchored at top and bottom of fan housing or building structure for support. Sides of each damper frame to be connected to the channels. Holes in channel allow damper drive blade shafts to pass through channel for direct shaft-mounting of actuators. Face open side of channel downstream of airflow, except for exhaust air dampers.
- 13. Multiple Section Dampers: Mount flush within a wall or housing opening and receive vertical channel supports as described above or sheet metal stand out collars. Sheet metal collars, 12 inches (305 mm), must bring each damper section out of the wall to allow direct shaft-mounting of actuator on side of the collar.
- 14. Valve Sizing for Water Coil:
  - a. On/Off control valves shall be line size.
  - b. Modulating control valve body size may be reduced, at most, two pipe sizes from the line size or not less than half the pipe size. The BAS contractor shall size water coil control valves for the application as follows:
    - 1) Booster-heat valves shall be sized not to exceed 4-9 psi differential pressure. Size valve for 50 percent valve authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.
    - 2) Primary valves: Sized not to exceed 5-15 psi differential pressure. Size valve for 50 percent valve authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.
- 15. Butterfly valves: Size for modulating service; 60-70 degree rotation. Design velocity: 12 feet (3658 mm) per second or less when used with standard EPDM seats.
  - a. Valve mounting arrangements shall comply to the following:
    - 1) Unions shall be provided on ports of two-way and three-way valves.
    - 2) Install three-way equal percentage characterized control valves in a mixing configuration with the "A" port piped to the coil.
    - 3) Install 2.5 inches (64 mm) and above, three-way globe valves, as manufactured for mixing or diverting service to the coil.

## 2.19 ENCLOSURES

**\*\* NOTE TO SPECIFIER \*\* Insert paragraphs as required; sample requirements follow.**

- A. BAS Control equipment shall be provided and installed where shown on the associated HVAC Drawings and where needed for complete installation of BAS components. Coordinate mounting locations with other trades.
- B. Controllers, power supplies and relays shall be mounted in enclosures. These items may also be mounted within the HVAC equipment control section if permitted by the HVAC equipment manufacturer, and if adequate space is provided.
- C. Enclosures shall be designed for control and instrumentation applications, able to be mounted directly on the wall, and capable of adequately protecting the enclosed product in the environment in which it is mounted.
- D. Enclosures shall not be mounted directly on HVAC equipment such as air handling unit housings. Enclosures shall be pedestal base or wall mounted.
- E. Enclosures: NEMA 1 or as required by location and local code requirements when located in a clean, dry, indoor environment. Indoor enclosures: NEMA 12 or as required by location and local code requirements when installed in other than a clean environment. Outdoor

Enclosures and Enclosures in Wet Ambient Conditions: Weatherproof.

- F. Control Enclosures: Hinged doors, key lock latch; single key
- G. Laminated plastic nameplates, 0.125 inches (3 mm) thick, for enclosures in any mechanical room or electrical room. Place location and unit served on easy to read nameplate.

## 2.20 CONNECTED POWER SMART OUTLETS AND BACNET® IP INTEGRATION HUB

- A. The solution provides complete energy monitoring and control of receptacles. Each outlet enables remote monitoring and control to help reduce energy consumption or maintain power supply to critical assets and is capable of advanced temperature detection enhances user safety.
  - 1. All Smart Outlets and Hubs shall be supplied by the Division 23 09 23 Contractor and outlets (not Hubs) provided to the Division 26 Electrical Contractor for installation.
  - 2. After installation and power up has been completed by Division 26 Electrical Contractor, Division 23 09 23 Contractor shall configure, commission and integrate all Smart Outlets and Hubs into the BMS.

**These two items MUST be added to Division 26 27 26:**

- 1. All Smart Outlets and Hubs shall be supplied by the Division 23 09 23 Contractor and outlets (not Hubs) provided to the Division 26 Electrical Contractor for installation.
- 2. After installation and power up has been completed by Division 26 Electrical Contractor, Division 23 09 23 Contractor shall configure, commission and integrate all Smart Outlets and Hubs into the BMS.

- B. Related Sections

- 1. Division 26 – Electrical: Electrical systems and components - Low-Voltage Distribution Equipment (26 27 26).

- C. Features

- 1. Graphically display each outlet on floorplan graphics at the BMS and drill down capability, for full solution insights.
  - a. Add or create Energy Usage Dashboard incorporating all Utility Meters and Smart Outlets as per Owner's requirements.
- 2. Energy metering at each outlet and individual receptacle.
- 3. Local control over receptacle state ON/OFF.
- 4. Low and high power levels per receptacle.
- 5. Remote automatic control over receptacle state from BMS ON/OFF/LOCK ON/LOCK OFF.
- 6. Grouping of outlets and / or receptacles.
- 7. Scheduling of receptacles / groups.
- 8. Ability to raise alerts and / or change receptacle states depending upon temperature at outlet.
- 9. Internal outlet temperature monitoring.
- 10. Ability to raise alerts and / or change receptacle state dependent upon power levels.
- 11. E-mail option for alerts.
- 12. Ability to update firmware in the field.
- 13. Restart outlet button.

- D. Outlet / Outlet Specifications

- 1. Operating Voltage: 95 – 125VAC @ 60Hz.
- 2. Standby power consumption: <0.5W.
- 3. Current rating: 15A.
- 4. Terminal capacity: Live and neutral 2 x 14AWG earth, 1 x 14AWG (stranded), Single earth terminals.

5. IP rating: IP2X.
  6. Active power consumption: <1W.
  7. RF Mesh network.
  8. Outlet to outlet: 10m (32.8 feet).
  9. Number of hops: <=3.
  10. Frequency: 2402MHz – 2483MHz.
  11. BLE: Commissioning purposes ONLY.
  12. BQB (Bluetooth qualification body): D058742.
  13. Antenna type: Built-in.
  14. Operating temperature: +32°F – +113°F (0°C - +45°C).
  15. Storage temperature: -4°F – +140°F (-20°C - +60°C).
  16. Humidity: 0 – 95% non-condensing.
  17. Maximum installation altitude: 2000 meters (6561.7 feet).
  18. Back boxes: Standard junction box. Do not mount or use as a trailing outlet or where they may be subject to excessive moisture or damp conditions.
  19. Warranty: 10 years.
- E. Smart Outlet Standards and Approvals
1. UL 498 B – CSA C22.2 No. 42.
  2. UL 514D – CSA C22.2 No. 42.1-13.
  3. RoHS 3.
  4. Proposition 65.
  5. TSCA.
  6. FCC Rules and Regulations Part 15 Subpart C, RSS-247 issue 3 August 2023.
  7. FCC EMC: 47 CFR Part 15 Subpart B, IEEE/ANSI C63.4-2014.
  8. ISED EMC: ICES-003 issue 7: October 2020, ANSI C63.4-2014 amended as per ANSI C 63.4a-2017.
  9. FCC RF: KDB447498 D01 General RF Exposure V06.
  10. IC RF: RSS-102 issue 5, March 2015
- F. HUB Specifications
1. Operating Voltage: 95 – 125VAC @ 60Hz.
  2. Standby power consumption: <2W.
  3. Current rating: 15A.
  4. Terminal capacity: Live and neutral 1 x 14AWG (stranded).
  5. IP rating: IP2X.
  6. Active power consumption: <5W.
  7. RF Mesh network.
  8. Outlet to HUB: 25m (82.0 feet).
  9. Number of hops: <=3.
  10. BLE: Commissioning purposes ONLY.
  11. BQB (Bluetooth qualification body): D058742.
  12. Antenna type: Built-in.
  13. Wired Communication: RJ45 connector, BACnet® IP (ASHRAE-135 Annex J), BACnet® Protocol Revision: 18.
  14. Operating temperature: +32°F – +113°F (0°C - +45°C).
  15. Storage temperature: -4°F – +140°F (-20°C - +60°C).

16. Humidity: 0 – 95% non-condensing.
  17. Maximum installation altitude: 2000 meters (6561.7 feet).
  18. Back boxes: Standard junction box.
  19. Warranty: 10 years
- G. HUB Standards and Approvals
1. UL 62368-1 CSA C22.2 No. 62368-1:19.
  2. UL 2043, Fourth Edition, dated October 2, 2013.
  3. RoHS 3.
  4. Proposition 65.
  5. TSCA.
  6. FCC Rules and Regulations Part 15 Subpart C, RSS-247 issue 3 August 2023.
  7. FCC EMC: 47 CFR Part 15 Subpart B, IEEE/ANSI C63.4-2014.
  8. ISED EMC: ICES-003 issue 7: October 2020, ANSI C63.4-2014 amended as per ANSI C 63.4a-2017.
  9. FCC RF: KDB447498 D01 General RF Exposure V06.
  10. IC RF: RSS-102 issue 5, March 2015.
- 2.21 PLC – PROGRAMMABLE LOGIC CONTROLLER
- A. Hardware applicable Codes and Standards
1. EN/IEC 61131-2:2007: Programmable Controllers – Part 2: Equipment requirements and tests.
  2. EN/IEC 61131-3: Programmable Controllers – Part 3: Programming environment.
  3. IN 61000-6-4:2007 + A1:2011: Emission standard for industrial environments.
  4. EN 63000:2018: Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances.
  5. 2014/30/EU: Electromagnetic Compatibility (EMC).
  6. 2014/35/EU: Low Voltage Directive (LVD).
  7. 2014/65/EU: ROHS Directive.
  8. EAC Mark of Conformity for Machinery Exports to Russia, Kazakhstan or Belarus.
  9. UL Compliance, according to the following conditions.
- B. Software applicable Codes and Standards
1. All protocols to be FULLY cyber secure acc. ANSI 62443-3-3 SL3 and follow programming language acc. IEC 61131-3.
  2. Modbus TCP according to IEC 61158.
  3. Profinet version: IEC 61158-1.
  4. Profinet conf. class: A.
  5. IEC 60870-5-104: Application library for server / controlled station definition (slave).
  6. M-Bus according to EN 13757.
  7. Ethernet / Fast Ethernet according to IEEE 802.3 / 802.3u.
  8. OPC UA extensions with historical data access, alarms, events.
  9. MQTT, IoT protocol.
  10. BACnet® Secure Connect with MSTP and IP integrations, BTL Certification.
  11. CAN raw frames, CAN open, CAN J1939.
- C. The PLC shall provide the following hardware features as a minimum:
1. Power supply 24VDC incorporated in the CPU main board. No separate module required.

2. 180 x 101 x 140 mm (W x H x D). 4 slots for IO modules included.
  3. DIN rail mountable.
  4. 32 Bit microprocessor > 900 MHz.
  5. 10 MB user program memory.
  6. 50 MB program data memory.
  7. 128 KB non-volatile persistent program data memory.
  8. Memory extension with Micro SD card up to 32 GB.
  9. Battery-less real time clock back-up for up to 10 days.
  10. Onboard interfaces:
    - a. 1x RS485.
    - b. 2x Ethernet for network separation. One ETH interface with 2 port switch.
    - c. CAN, galvanically isolated.
    - d. 1 slot for additional RS485 interface.
    - e. USB device as service interface.
    - f. USB host for license dongle.
    - g. 2 Interrupt inputs.
    - h. Watchdog relay.
  11. Wiring connectors are removable.
  12. IOs can locally be modularly expanded up to 1024 IOs.
  13. IO update via process image.
  14. Digital IO update cycle: 2ms.
  15. Scanning time for all digital local IOs: minimum 2ms.
  16. CPU processing cycle: minimum 1ms.
  17. CPU instruction processing time:
    - a. Bit: 0.01  $\mu$ s.
    - b. Word: 0.046  $\mu$ s.
    - c. Int: 0.043  $\mu$ s.
    - d. Float: 0.066  $\mu$ s.
  18. Operating temperature: 32 to 131°F (0 to 55°C).
  19. Storage temperature: -13 to 167°F (-25 to 75°C).
  20. Relative humidity: 10 to 95% RH, non-condensing.
- D. General Input / Output Requirements
1. The IO modules shall be connected locally in a modular way to the CPU or an IO extension base unit.
  2. Up to 1024 IOs can be connected to the local IO bus.
  3. The IO bus shall be high speed to allow a refresh rate of 1024 digital IOs within less than 2ms.
  4. IO modules can be added or exchanged during the whole life cycle without the need to exchange the CPU.
  5. The local IOs can also be extended using Remote IOs by up to min. 4'096 IOs per CPU.
  6. The IO modules shall support up to 16 channels per module.
- E. Digital Inputs
1. Digital inputs, 15 to 30VDC, up to 16 inputs per module.
  2. Input delay 8ms or 0.2ms.

3. Removable spring terminal blocks for up to 2.5mm square.
- F. Digital Outputs
1. Digital outputs transistor, 10 to 32VDC/0.5A, up to 16 outputs per module.
  2. Digital outputs relay, 2A/50VDC, 2A/250VAC, make or break, up to 6 outputs per module.
  3. Digital outputs relay, 2A/50VDC, 2A/48VAC, make and changeover, up to 8 outputs per module.
  4. Digital outputs relay with manual operation, 2A/50VDC, 5A/250VAC, make and changeover, 4 outputs per module.
- G. Combined Digital Input/Output Modules
1. Input: 24VDC, output: 18 to 30VDC, 16 IO per module configurable as input or output in groups of 4.
- H. Analog Inputs
1. Analog Inputs for 0 to 10V, 0 to 20mA, Pt1000/Ni1000, 10Bit, 8 inputs per module.
  2. Analog Inputs for 0 to 10V, 0 to 20mA, Pt1000/Ni1000, 12Bit, 8 inputs per module.
  3. Universal Input module 0 to 10V, 0 to 20mA, Pt/Ni1000, configurable, 12Bit, 8 inputs per module.
  4. Universal Input module -10V to +10V, -20mA to +20mA, Pt/Ni1000, Ni1000 L&S, NTC10k/NTC20k, configurable via software, 13Bit, 8 inputs per module.
  5. Analog Inputs for 0 to +10V, -10V to +10V, 0 to 20mA, 12Bit, 7 inputs per module, electrical isolated.
  6. Analog Inputs for temperature TC type J, K and 4-wire Pt/Ni 100/1000, 16Bit, 4 inputs per module, electrical isolated.
- I. Analog Output
1. Analog Outputs for 0 to +10V, 0 to 20mA, 4 to 20mA, 8Bit, 4 outputs per module.
  2. Universal Analogue Output module for 0 to +10V/-10V to +10V, 0 to 20mA/4 to 20mA, 12Bit, 4 outputs per module.
  3. Analog Outputs for 0 to +10V, 0 to 20mA/4 to 20mA, 8Bit, 4 outputs per module.
  4. Analog Outputs for 0 to +10V/-10V to +10V, 0 to 20mA/4 to 20mA, 10Bit, 4/6 outputs per module, electrical isolated.
  5. Analog Outputs with manual operation, 0 to 10V, 10Bit, 4 outputs per module.
- J. Combined Analog Input/Output Modules
1. Analog Input/Output module, 4 inputs: 0 to 10V, 0(4) to 20mA, Pt1000, Pt500, Ni1000; 2 Outputs: 0 to 10V, 0(4) to 20mA, electrical isolation.
- K. Fast Counter Modules
1. Module with 2 or 4 counters. 2+1 configurable inputs 24VDC per counter. 1 output per counter 10 to 30VDC/500mA. Counting range 0 to 16,777,215 (24Bit). Counting frequency 10kHz to 150 kHz.
- L. CPU Redundancy
1. Two PLC Controllers can be turned into a redundant pair of PLCs by System Configuration. They operate as a "Hot Standby" System where one Controller is configured as Primary PLC and the other as Secondary PLC. They are connected via an IP-Link to Synchronize their State. One PLC is acting as the Active Controller and the other PLC is in Passive Mode. One of the Tasks inside an Application can be configured as being the redundant Task, means the Task execution is time synchronized by the Active Controller. In addition, Data areas can be assigned to be in scope for synchronization.

2. Inputs and Outputs are connected to the process by using Ethernet Remote IO stations. Both PLCs receive the Input Data while the Active Controller is driving the Outputs cyclically.
  3. In case of an interruption of the Synchronization Link or any other PLC failure, the remaining PLC enters Standalone Mode and access the remote IO Stations. The PLC will continue to operate the application program.
  4. The PLCs will remain running the logic/sequence until the Synchronization Link is re-established, and the PLCs are triggered either by the Application Program or the Engineering Tool to be Synchronized again.
  5. Also in normal synchronized operation, the Active/Passive role can be switched over. During the switch over time (<100ms) the Outputs will not change their state (bump-less).
  6. A PLC can also be switched in Passive Mode for maintenance. In this case the Other PLC enter Standalone and takes over the Control. The Controller can be re-synchronized at any time by the Engineering Tool.
- M. Cyber Security
1. The Control System shall be aligned with at least the international Product Security Standard IEC 62443-3-2 and IEC 62443-3-3, Security Level 3 (SL3).
  2. The system shall use Unified Role Based Account Management to grant access permissions of Configuration, Status and Process Data individually to free definable Roles. These Roles are assigned to User-Profiles where the Users are inheriting from one Profile.
  3. The Controller shall report issues like Log-In, Start-Up messages, System Setting changes, etc. within a non-volatile Audit Log with adjustable size and Severity (Debug, Info, Notice, Warning, Error, Exception).
  4. The Controller shall provide mechanisms for a full Back up where the Configuration, Application Program with its related Web Pages and Certificates can be completely restored.
  5. The System shall provide an option for factory reset with enable and the choice of removing any user stored.
  6. The Controller shall have secure boot with signed firmware.
  7. All Data on the controller and memory card shall be encrypted.
- N. Network
1. The Controller shall support a Hostname and Domain which may be configured or received by the DHCP.
  2. The two independent Network Interfaces shall support IPv4 and IPv6 addresses which can be manually assigned or received by DHCP with the option to enable the reception for DNS Server List, Hostname, Domain Name and Gateway.
  3. The Controller shall support a third IP based communication port via USB-RNDS for local access of the Engineering tool, Web Browser, and any other IP Protocol Client. The RDNS Address is adjustable.
  4. A list of DNS Servers shall be maintained automatically or manually, see DHCP Options.
- O. Network Time Protocol
1. The Controller shall support NTP as Client and Server with the option for Encrypted Messages, the Keys are configurable.
- P. Real Time Clock
1. The Controller shall support a Real Time Clock for UTC and Local Time. The Time-Zone is adjustable, and the Time can be set manually or copied from the Engineering Tool PC.

- Q. Firewall and Internet Detector
1. All interfaces shall be protected by a free configurable firewall with options define a list of rules to filter In- and Outgoing traffic for Protocols, IP-Addresses, Ports and Stateful Filtering.
  2. In addition, a detector for connection to the open Internet is capable perform a scan regular on an adjustable schedule to report the Status. To protect the device from unintended Internet connectivity an option supports automatically Port Shut Down where the open Internet was detected.
- R. Webserver and Process Data Access (WebDav)
1. The embedded Webserver can be enabled on dedicated Network and USB Ports by options to listen on adjustable HTTPS Ports, enable Process Data Access and Cross-Origin Resource Sharing.
  2. The local file system shall be managed through WebDav and the Engineering Tool.
  3. The embedded OPC-UA Server shall provide options to enable, allow Reverse Connect. The Security Policies can be adjusted as None, Basic256SHA256, AES128SHA256\_RSA\_OAEP & ES128SHA256\_RSA\_PSS.
  4. Messages shall be Secured by None, Sign and Sign & Encrypt.
  5. Authentication shall support Anonymous and authenticated (User Name and Password) access.
- S. Remote Monitoring
1. The System shall provide a secured API (Restful API) for remote monitoring and maintenance of all Device Status and Settings.
- T. Security Settings Download
1. Configuration and Security Settings shall be maintained individually in run time by upload, download partially or complete.
- U. Networking / Communication
1. The PLC shall provide open interfaces and communication protocols to allow the connection and integration into any system. It shall be equipped with onboard Web/IT and serial RS485 interfaces. The communication interfaces shall be extendable in a modular way with optional plugin modules for various protocols and fieldbus systems.
  2. Onboard interfaces shall include:
    - a. 1 Ethernet, single port.
    - b. 1 Ethernet 2 port switch.
    - c. The Ethernet interfaces can have two different IP addresses for network separation or redundant network path.
    - d. 1 RS485.
    - e. 1 slot for additional RS485 interface.
    - f. CAN interface supporting CAN raw frames, CANopen, CAN J1939.
    - g. USB device RNDIS as service and programming interface.
    - h. USB host as license dongle.
  3. Supported protocols by the operating system shall include:
    - a. BACnet® IP Secure Connect.
    - b. OPC-UA (client & server).
    - c. Modbus TCP (client & server), Modbus RTU (master & slave).
    - d. Profinet.
    - e. IEC 60870-5-104 for telecontrol in infrastructure.
    - f. MQTT for cloud connection.
    - g. S-Bus.

- h. DHCP.
  - i. HTTPS.
  - j. OAI (Object Access Interface) for web access.
  - k. WebDav for secure file transfer.
  - l. SMTP (email).
  - m. NTP (client & server).
  - n. IEEE802.1x EAP-TLS (port security).
  - o. Support for SNMP.
  - p. Free programmable interface (IP and serial) to implement any communication protocol.
4. Optional modular plug-in modules shall include:
- a. Extendable with up to 8 additional interfaces.
  - b. BACnet® MSTP.
  - c. M-bus.
  - d. DALI.
  - e. RS485 or RS232 (free programmable).
- V. Secure Programming
1. The Application shall be free programmable per IEC 61131-3 including the most recent version supporting Object Oriented Methods and dynamic Memory management. The Engineering tool supports language editors for CFC (Continuous Function Chart), CFC page oriented, LD (Ladder Logic), FBD (Function Block Diagram), SFC (Sequential Function Chart), ST (Structured Text) and for legacy backward compatibility IL (Instruction List).
  2. The Device shall be capable to execute in parallel multiple Applications. These Applications must be isolated in terms of memory and task resources, so that an exceptional state in one Application doesn't impact the reliability of the parallel Applications.
  3. Each Application shall hold one or more Tasks to execute a List of Programs. The Task Priority is adjustable in (32 Steps, from Real Time to none-real time). Tasks can be configured as Cyclic (Cycle Time  $\geq 1\text{ms}$ ), Status, Event, External and Freewheeling. A Task Monitor provides an online execution status with statistics in micro- seconds resolution about Task Schedule, Execution Time (actual, Min, Max) and Jitter (Act, Min, Max).
  4. The Engineering Tool shall provide Low Level System Functions / Libraries (Layer 2) to control the Device Resources from the Application program. Device Resources: Applications, Tasks, Memory, Encryption TLS, Certificates, Variables, Symbolic-Names, Serial-, CAN- and Ethernet - Communication Interfaces (incl. UDP, TCP, TLS, ICMP, DHCP/DNS), Redundancy, Real Time Clock RTC, Audit Log System and File System.
  5. The Engineering Tool shall provide System Libraries for seamless integration of Remote IOs, Application specific functions like Historical Data Recording, Alarming, Control Loops, Scheduling, typical HVAC solutions, and more.
- W. HMI for Control, Monitoring and Visualization
1. HMI is the local operator interface, displaying the process parameters on the HMI screens along with schematic.
  2. The HMI shall be HMTL5 Chromium browser based on Linux. The web application is stored in the PLC and the HMI is only displaying the web pages.
  3. The system and process are visualized in the form of web pages and can be requested from the web server via a browser.

4. The web browser shall be based on open standards like HTML5 and uses HTTP(S) as communication protocol. No proprietary communication driver shall be needed.
5. Web Panels shall provide a completely interactive user interface and shall support the HTML5 browser based on Linux, which is modern and easy to understand.
6. The web pages can freely be programmed and designed in an easy-to-use tool by the application programmer.
7. The web panels support the web visualization of manufacturer-independent controllers.
8. HMI shall support high cyber security level to prevent from unauthorized access.
9. The HMI shall be high quality, industrial grade with long cycle life >10 years.
10. The HMI shall be designed for control cabinet installation.
11. The display shall be resistive or capacitive touch screen in total glass design, resistant to scratches, UV and chemicals.
12. HMI Capacitive screen operating temperature of -4°F to 140°F (-20°C to 60°C).
13. HMI Resistive screen operating temperature of 32°F to 122°F (0°C to 50°C).
14. For optimal integration into the system, at least one Ethernet port and one USB port shall be provided.
15. HMI shall include integrated real time clock, RTC back-up. The display shall provide wide angle visibility and ensure at least the following resolution.

Display size	Minimum resolution
< 4.9"	130k pixels
5"-9.9"	380k pixels
10"-14.9"	1M pixels
15"-20.9"	1M pixels
>21"	2M pixels

16. HMI shall have IP66 front and shall operate on 24 VDC power supply.
17. The following certifications shall be supported as minimum: IECEx, UL.

X. SCADA and Supervision

1. The SCADA shall support role-based user access control. It shall be capable of detailed description of user rights within a system up to individual data points including and not limited to individual start page, accessible project parts, individual language, etc. All user activities and security relevant events shall be recorded in the Audit Log and can be traced.
2. Integration of PLC into SCADA system may require customization of existing communication drivers, provision of wizards and handling of a specific license model.
3. The Contractor shall provide system software based on server/thin-client architecture, designed around the open standards of web technology. The SCADA server shall communicate using Ethernet and TCP. Server shall be accessed using a web browser over Owner intranet and remotely over the Internet.
4. The intent of the thin-client architecture is to provide the operator(s) complete access to the SCADA system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. Microsoft, Firefox, and Chrome browsers (current released versions), and Windows as well as non-Windows operating systems.
5. The system shall be Niagara Supervisors based on Niagara 4.x Platform.
6. The SCADA server software shall support at least the following server platforms (Windows 10, Server 12). The BMS server software shall be developed and tested by

the manufacturer of the system stand-alone controllers and network controllers/routers.

7. All communication drivers are supported in Supervisor, with a focus on secured communication as OPC-UA and BACnet® SC. In general, controller related data such as controller type, addresses, descriptions etc. must be deployed automatically in supervisor on Controller property sheet.

## 2.22 OTHER CONTROL SYSTEM HARDWARE

- A. Motorized control dampers that will not be integral to the equipment shall be furnished by the Control System Contractor. Control damper frames shall be constructed of galvanized steel, formed into changes, and welded or riveted. Dampers shall be galvanized, with nylon bearings. Blade edge seals shall be vinyl. Blade edge and tip seals shall be included for all dampers. Blades shall be 16-gauge minimum and 6 inches wide maximum and frame shall be of welded channel iron. Damper leakage shall not exceed 10 CFM per square foot, at 1.5 inches water gauge static pressure. Honeywell is the basis of design.
- B. Control damper actuators shall be furnished by the Control System Contractor. Two-position or proportional electric actuators shall be direct-mount type sized to provide a minimum of 5 in-lb torque per square foot of damper area. Damper actuators shall be spring return type. Actuators shall be heavy-duty electronic communicating type for positioning automatic dampers in response to a communicating signal from the DDC Controller to which they're connected. Motor shall be of sufficient size to operate damper positively and smoothly to obtain correct sequence as indicated. All applications requiring proportional operation and actuator analytics shall utilize a two wire, polarity insensitive bus that provides direct communications between a communicating Actuator device and its associated DDC Controller (NPICU, PICU, AUC or AVC). All actuators shall be UL listed. Honeywell is the basis of design.
  1. The Actuator shall accept the following communicated commands:
    - a. Actuator Position Command.
    - b. Actuator Travel Time.
  2. The Actuator shall provide the following feedback to the Controller:
    - a. Actual Position.
    - b. Cycle Count.
    - c. Status.
    - d. Overridden.
  3. The actuator microprocessor control shall provide redundant position feedback methods, feedback potentiometer and counting motor commutations, for accurate position tracking.
  4. The actuator minimum design life shall be: 60,000 full stroke cycles, 60,000 spring-return cycles, and 1,500,000 repositions at rated torque and temperature.
    - a. The actuator shall be manufactured under ISO 9001 International Quality Control Standards and be warranted for five years.
  5. The DDC Controller (NPICU, PICU, AUC or AVC) shall provide analytics to provide system alerts at the GUI for the following:
    - a. Specific Actuator has reached approximately 90 % of life and must be replaced or it will fail soon.
    - b. Specific Actuator position fault has been detected and should be checked.
- C. Control Valves - ½" to 1" Zone Control Valves: Zone control valves shall be 2-way, or 3-way pattern as shown. Valve housing shall consist of forged brass with a nominal pressure rating no less than 290 psi. Valve ball shall consist of chemically nickel-plated brass. Valve shall have a stainless-steel stem with EPDM O-ring. Modulating valves shall be profiled to provide equal percentage flow. On/off valves shall be full port. Valves shall be Honeywell. Both 2-way and 3-way valves shall have PTFE ball sealing to provide 87 psi close-off with a 22 lb-

in. actuator for 1/2, 3/4 and 1 inch sizes. Valves shall be available with threaded (fNPT) end connections. Factory installed actuators shall be available in 24-volt modulating, 24-volt on/off and line voltage on/off in both non-fail-safe and electronic fail-safe configurations.

- D. Control Valves: Control valves shall be 2-way, or 3-way pattern as shown and constructed for tight shutoff at the pump shut-off head or steam relief valve pressure. Control valves shall operate satisfactorily against system pressures and differentials. Two-position valves shall be 'line' size. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (unless otherwise noted or scheduled on the drawings). Valves with sizes up to and including 2 inches (51 mm) shall be "screwed" configuration and 2-1/2 inches (63.5 mm) and larger valves shall be "flanged" configuration. All control valves, including terminal unit valves, less than 2 inches (51 mm) shall be ball valves. Electrically actuated control valves shall include spring return type actuators sized for tight shut-off against system pressures (as specified above) and, when specified, shall be furnished with integral switches for indication of valve position (open-closed). Pneumatic actuators for valves, when utilized, shall be sized for tight shut-off against system pressures (as specified above). Honeywell is the basis of design.
- E. Control Valve Actuators: Actuators for VAV terminal unit heating coils shall be "drive-open; drive-closed" type. All actuators shall have inherent current limiting motor protection. Valve actuators shall be 24-volt, electronic type, modulating or two-position as required for the correct operating sequence. Actuators on valves needing 'fail-safe' operation shall have spring return to Normal position. All applications requiring proportional operation and actuator analytics shall utilize a two wire, polarity insensitive bus that provides direct communications between a communicating Actuator device and its associated DDC Controller (NPICU, PICU, AUC or AVC). All valve actuators shall be UL listed. Honeywell is the basis of design.
1. The Actuator shall accept the following communicated commands:
    - a. Actuator Position Command.
    - b. Actuator Travel Time.
  2. The Actuator shall provide the following feedback to the Controller:
    - a. Actual Position.
    - b. Cycle Count.
    - c. Status.
    - d. Overridden.
  3. The actuator microprocessor control shall provide redundant position feedback methods, feedback potentiometer and counting motor commutations, for accurate position tracking.
  4. The actuator minimum design life shall be: 60,000 full stroke cycles, 60,000 spring-return cycles, and 1,500,000 repositions at rated torque and temperature.
    - a. The actuator shall be manufactured under ISO 9001 International Quality Control Standards and be warranted for five years.
  5. The DDC Controller shall provide analytics to provide system alerts at the GUI for the following:
    - a. Specific Actuator has reached approximately 90 % of life and must be replaced or it will fail soon.
    - b. Specific Actuator position fault has been detected and should be checked
- F. All control valves 2-1/2 inches (63.5 mm) or larger shall have position indication. All hot water control valves shall be Normally Open arrangement; all chilled water control valves shall be Normally Closed arrangement. Honeywell is the basis of design.
- G. 6-Way Control Valves: Control valves shall be 1/2" 6-way pattern ball valves as shown and constructed for tight shutoff against system total dynamic head pressure. 6-way control valves shall have a static pressure rating of 600psi, close-off pressure rating of 200 psi, and

a maximum differential pressure rating of 50 psid. 6-way control valves shall be rated for 0 % leakage at both A-AB port and B-AB port according to EN 12266-1:2003 and have an Equal % flow characteristic curve with 100:1 rangeability. 6-way control valves body construction shall be nickel-plated forged brass, stainless steel ball & stem, PTFE seats, precision machined brass characterizing disc, and EPDM Perox stem O-rings. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (unless otherwise noted or scheduled on the drawings). Valves shall be Female NPT configuration. All 6-way control valves shall be proportional (floating or two-position available) signal electrically actuated and shall include non-spring return type actuators sized for tight shut-off against system pressures (as specified above). Honeywell is the basis of design.

- H. Wall Mount Room Temperature sensors: Each room temperature sensor shall provide temperature indication to the digital controller, provide the capability for a software-limited occupant set point adjustment (warmer-cooler slider bar or switch) and limited operation override capability. Room Temperature Sensors shall be 20,000-ohm thermistor type with a temperature range of -40 degrees to 140 degrees F (-38 degrees to 60 degrees C). The sensor shall be complete with a decorative cover and suitable for mounting over a standard electrical utility box. These devices shall have an accuracy of 0.5 degrees F (.024 degrees C) over the entire range. Honeywell is the basis of design.
- I. Intelligent Wall Module shall include:
  - 1. Color touch screen.
  - 2. Temperature Sensor only or Temperature and Humidity Sensors.
  - 3. Vertical or Horizontal orientation.
  - 4. Ability to display up to three of the following parameters:
    - a. Space Temperature.
    - b. Space Humidity.
    - c. Space Setpoint.
    - d. Outdoor Temperature.
    - e. Outdoor Humidity.
    - f. Current Time.
    - g. Or any one other parameter in the controller
- J. Duct-mounted and Outside Air Temperature Sensors: 20,000-ohm thermistor temperature sensors with an accuracy of +/- 0.2 degrees C. Outside air sensors shall include an integral sun shield. Duct-mounted sensors shall have an insertion measuring probe of a length appropriate for the duct size, with a temperature range of -40 degrees to 160 degrees F (-38 degrees to 71 degrees C) The sensor shall include a utility box and a gasket to prevent air leakage and vibration noise. For all mixed air and preheat air applications, install bendable averaging duct sensors with a minimum 8 feet (2438 mm) long sensor element. These devices shall have accuracy of 0.5 degrees F (.024 degrees C) over the entire range. Honeywell is the basis of design.
- K. Humidity sensors shall be thin-film capacitive type sensor with on-board nonvolatile memory, accuracy to plus or minus two percent (2 %) at 0 to 90 % RH, 12 - 30 VDC input voltage, analog output (0 - 10 VDC or 4 – 20 mA output). Operating range shall be 0 to 100 % RH and 32 degrees to 140 degrees F (0 degrees to 60 degrees C). Sensors shall be selected for wall, duct, or outdoor type installation as appropriate. Honeywell is the basis of design.
- L. Carbon Dioxide Sensors (CO2): Sensors shall utilize Non-dispersive infrared technology (N.D.I.R.), repeatable to plus or minus 20 PPM. Sensor range shall be 0 - 2000 PPM. Accuracy shall be plus or minus five percent (5 %) or 75 PPM, whichever is greater. Response shall be less than one minute. Input voltage shall be 20 to 30 VAC or DC. Output shall be 0 - 10 VDC. Sensor shall be wall or duct mounted type, as appropriate for the application, housed in a high impact plastic enclosure. Honeywell is the basis of design.

- M. Indoor Air Quality Multi Sensors: Sensors shall be capable of monitoring Temperature, Humidity, CO<sub>2</sub>, PM<sub>1.0</sub>, PM<sub>2.5</sub>, PM<sub>10</sub>, and TVOC. Output via BACnet® MS/TP or Modbus RTU. Sensors shall be wall mounted type with Air Quality Score, individual parameter description/ units incorporated into display. Air Quality score shall be based on CO<sub>2</sub>, PM<sub>2.5</sub>, and TVOC detected. Operating environment shall be 32 degrees to 122 degrees F (0 degrees to 50 degrees C) 0–95 % RH (No condensation). Input voltage shall be 24 VAC/VDC. Honeywell TR50-5D is the basis of design. Specifications by sensed medium are as follows:
1. Temperature: Measuring range 32-122°F (0-50°C), accuracy ±1.8°F degrees (±1°C).
  2. Humidity: Measuring range 0-100%, accuracy ±3 % RH (20%–80 % RH).
  3. Carbon Dioxide: Measuring range 0-9999ppm, accuracy ±75 PPM @ 400-1000ppm, ±40 PPM @ 1001-2000ppm.
  4. Particulate Matter: Measuring range 0-5000 µg/m<sup>3</sup>, accuracy ±10 µg/m<sup>3</sup>, 0-100 µg/m<sup>3</sup>, 101-500 µg/m<sup>3</sup>, ±10% reading
  5. Total VOC: Measuring range 0-9000 ppb, accuracy ±25% reading
- N. Current Sensitive Switches: Solid state, split core current switch that operates when the current level (sensed by the internal current transformer) exceeds the adjustable trip point. Current switch to include an integral LED for indication of trip condition and a current level below trip set point. Honeywell is the basis of design.
- O. Differential Analog (duct) Static Pressure Transmitters Provide a pressure transmitter with integral capacitance type sensing and solid-state circuitry. Accuracy shall be plus or minus 1 % of full range; range shall be selected for the specific application. Provide zero and span adjustment capability. Device shall have an integral static pickup tube. Honeywell is the basis of design.
- P. Differential Air Pressure Switches: Provide SPDT type, UL-approved, and selected for the appropriate operating range where applied. Switches shall have adjustable set points and barbed pressure tips. Honeywell is the basis of design.
- Q. Water Flow Switches: Provide a SPST type contact switch with bronze paddle blade, sized for the actual pipe size at the location. If installed outdoors, provide a NEMA-4 enclosure. Flow switch shall be UL listed.
- R. Temperature Control Panels: Furnish temperature control panels of code gauge steel with locking doors for mounting all devices as shown. All electrical devices within a control panel shall be factory wired. Control panel shall be assembled by the BMS in a UL-Certified 508A panel shop. A complete set of 'as-built' control drawings (relating to the controls within that panel) shall be furnished within each control panel.
- S. Pipe and Duct Temperature sensing elements: 20,000-ohm thermistor temperature sensors with and accuracy of +/- 1 % accuracy. Their range shall be -5 degrees to 250 degrees F (-20 degrees to 121 degrees C). Limited range sensors shall be acceptable provided they are capable of sensing the range expected for the point at the specified accuracy. Thermal wells with heat conductive gel shall be included. Honeywell is the basis of design.
- T. Low Air Temperature Sensors: Provide SPST type switch, with 15 degrees to 55 degrees F (-9 degrees to 13 degrees C), range, vapor-charged temperature sensor. Honeywell model L482A, or approved equivalent.
- U. Variable Frequency Drives: The variable frequency drive (VFD) shall be designed specifically for use in Heating, Ventilation, and Air Conditioning (HVAC) applications in which speed control of the motor can be applied. The VFD, including all factory installed options, shall have UL & CSA approval. VFD's shall include communications capability with DDC BMS via built-in interface card (Modbus or BACnet®). Honeywell is the basis of design.
- V. Relays: Start/stop relay model shall provide either momentary or maintained switching action as appropriate for the motor being started. All relays shall be plugged in, interchangeable, mounted on a subbase and wired to numbered terminals strips. Relays installed in panels shall all be DPDT with indicating lamp. Relays installed outside of controlled devices shall be

- enclosed in a NEMA enclosure suitable for the location. Relays shall be labeled with UR symbol. RIB-style relays are acceptable for remote enable / disable.
- W. Emergency Stop Switches: Provide toggle-type switch with normally closed contact. Switch shall be labeled "AIR HANDLER EMERGENCY SHUTOFF, NORMAL - OFF."
  - X. Transducers: Differential pressure transducers shall be electronic with a 4-20 mA output signal compatible to the Direct Digital Controller. Wetted parts shall be stainless steel. Unit shall be designed to operate in the pressure ranges involved.
  - Y. Control Power Transformers: Provide step-down transformers for all DDC controllers and devices as required. Transformers shall be sized for the load, but shall be sized for 50 watts, minimum. Transformers shall be UL listed Class 2 type, for 120 VAC / 24 VAC operation. Honeywell is the basis of design.
  - Z. Line voltage protection: All DDC system control panels that are powered by 120 VAC circuits shall be provided with surge protection. This protection is in addition to any internal protection provided by the manufacturer. The protection shall meet UL, ULC 1449, IEEE C62.41B. A grounding conductor, (minimum 12 AWG), shall be brought to each control panel.
  - AA. Electric Meters: Honeywell is the basis of design. See Section 26 27 13.
  - BB. HMI: Honeywell is the basis of design.
    - 1. Provide HTML5 IP touchscreen monitors in specified sizes: 4.3", 7", 10.1", 15.6" or 21.5".

## PART 3 EXECUTION

### 3.1 EXAMINATION AND PREPARATION

- A. Carefully inspect installed work of other trades. Verify work is complete to where work of this Section may commence.
- B. Do not proceed with installation until substrates have been prepared using methods recommended by manufacturer and deviations from manufacturer's recommended tolerances are corrected. Commencement of installation constitutes acceptance of conditions.
- C. If preparation is the responsibility of another installer, notify Architect and Owner's representative in writing of deviations from manufacturer's recommended installation tolerances and conditions.

### 3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions, approved submittals and in proper relationship with adjacent construction.
  - 1. Install in conduit, wiring and cable, and install equipment in first-class manner, using proper tools, equipment, hangers, and supports, and in locations as required for a neat, attractive installations. No material shall be exposed if it is possible to conceal it. Exposed material shall be installed only with consent of the Engineer.
  - 2. Install the system as recommended by the manufacturer, using only equipment recommended or acceptable to the manufacturer.
  - 3. Support sensors as recommended by the manufacturer where inside equipment, such as ductwork. Sensors in the space shall be in small, attractive housings designed for that purpose and mounted on electrical junction box.
  - 4. Control tubing shall be supported at frequent intervals to support sagging. Tubing run in exposed areas shall be run in an inconspicuous manner following natural building lines. In finished portions of the building, tubing shall be run concealed.
  - 5. Use extreme care making connections to other equipment, such as boilers and chillers. Safeties of equipment are not to be by-passed or overridden by the BAS.
  - 6. Install damper motors on outside of duct in warm areas, not in locations exposed to

outdoor temperatures.

7. Install labels to identify control components.
8. Provide equipment having moving parts and controlled by BAS with warning labels 2 inches (51 mm) in height, and in bright warning colors, stating equipment is remotely started by automatic controls. Post labels clearly in area of moving parts, including but not limited to belts, fans and pumps.
9. VAV and Terminal Unit Controllers:
  - a. Terminal unit controllers and actuators shall be factory mounted.
    - 1) Ship controller the terminal unit manufacturer for factory mounting.
    - 2) The Terminal Unit Manufacturer Shall:
      - a) Mount the combination controller, actuator and differential pressure sensor package on the terminal units.
      - b) Connect pressure sensing tubes to differential pressure sensor.
  - b. At the HVAC contractors option, the VAV terminal units maybe field mounted on the terminal units, in lieu of factory mounting. The HVAC contractor shall coordinate this work with the BAS Contractor and the Equipment Manufacturer.

### 3.3 LOCATION AND INSTALLATION OF COMPONENTS

- A. Locate and install components for easy accessibility; in general, mount 48 inches (1219 mm) above floor with minimum 36 inches (914 mm) of clear access space in front of units. Obtain approval on locations from Owner's representative prior to installation.
- B. Components including but not limited to instruments, switches, and transmitters; suitably wired and mounted to protect them from vibration, moisture, and high or low temperatures.
- C. Identify equipment and panels. Provide permanently mounted tags for panels.
- D. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections, and sized to suit pipe diameter without restricting flow.

### 3.4 INTERLOCKING AND CONTROL WIRING

- A. Interlock and control wiring. Install wiring neatly and professionally, per Division 16 and national, state and local electrical codes.
- B. Wiring as required by functions as specified and as recommended by equipment manufacturers, to serve specified control functions. Shielded low capacitance wire for communications trunks.
- C. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of control equipment with the Owner's representative prior to rough-in.
- D. Provide auxiliary pilot duty relays on motor starters as required for control function.
- E. Provide power for control components from nearest electrical control panel or as indicated on the electrical drawings; coordinate with electrical contractor.
- F. Install control wiring in mechanical, electrical, telephone and boiler rooms in raceways. Install other wiring neatly and inconspicuously per local code. If code allows, control wiring above accessible ceiling spaces may be run with plenum-rated cable (without conduit).

### 3.5 SOFTWARE

- A. Load and debug software for BAS. Operate to prove functionality of each system.
  1. Provide database generation.
  2. System displays: Show analog and binary object types within system; logically laid out for easy use by Owner. Provide outside air temperature indication on system displays associated with economizer cycles.
  3. At a minimum, run time totalization shall be incorporated for each monitored supply fan, return fan, exhaust fan, hot water and chilled water pumps. Warning limits for

each point shall be entered for alarm and or maintenance purposes.

4. Binary and analog object types (including zones) shall have the capability to be automatically trended.
  5. Analog inputs (High/Low Limits) and selected binary input alarm points to be prioritized and routed (locally or remotely) with alarm message per Owner's requirements.
- B. BAS Contractor: Review programs with Engineer in the programming stage. Make sure programmer understands Engineer's intent and that program will carry out that intent.
- C. Bound copy of the complete information on the equipment and components.
- D. Spare parts list. Identify equipment critical to maintaining integrity of operating system.

### 3.6 SYSTEM DEMONSTRATION, VALIDATION AND ACCEPTANCE

- A. Contractor will satisfactorily demonstrate operating sequence, daily and seasonal mode changes, and associated energy management routines for equipment controlled including:
1. Hot water systems.
  2. Chilled water systems.
  3. Air handling units.
  4. Exhaust air systems.
  5. VAV terminal units.
  6. Miscellaneous Equipment: Including but not limited to the following.
    - a. Ventilation systems.
    - b. Cabinet heaters.
    - c. Unit heaters.
- B. Contractor to satisfactorily demonstrate proper operation of associated system points as defined in Division 15, including but not limited to:
1. Analog input sensing device readings; temperature, humidity, pressure, flow, volume and CO2 sensors.
  2. Analog output controls; valves, dampers and speeds; including proper ranging.
  3. Binary input status readings.
  4. Binary output or two position controls; start/stops, open/closed, in/off.
  5. Pulsed inputs; flow meters, electric meters; including proper ranging.
- C. Upon Completion of Work:
1. Demonstrate complete operating system to Owner's representative.
  2. Certificate stating control system has been tested and adjusted for proper operation.

### 3.7 TRAINING

- A. By BAS manufacturer. Utilize manuals, as-built documentation and on-line help utility.
- B. Operator Training: Sixteen (16) hours encompassing, but not limited to the following topics.
1. Sequence of operation review.
  2. Log in, log out.
  3. Password assignment and modification.
  4. Operator privileges assignment and modification.
  5. Selection of displays and reports.
  6. Commanding of points, including disable/enable.
  7. Use of dialog boxes and menus.
  8. Modifying warning limits, alarm limits and start-stop times.
  9. Modification of color graphic displays.
  10. Modification of alarm and status descriptors.

11. System initialization.
  12. Backup, download and initialization of DDC in controllers.
  13. Request and viewing of trend logs.
  14. Archive and purge of historical data.
  15. System maintenance procedures.
- C. Programmer Training: Eight (8) hours encompassing but not limited to the following topics.
1. Software review of sequence of operation.
  2. Use of programming tool and any additional plug-ins.
  3. Modification of control programs, including Building Controller, Advanced Application and Application Specific programs.
  4. Add, modify and delete data points.
  5. Use of diagnostics.
  6. System maintenance procedures.
  7. Review of initialization.
  8. Upload/download and off-line archiving of system software.
  9. Creating and modifying color graphics
  10. Operator training performed on site/off site. Coordinate dates/times with Owner.
  11. Tuition for at least one individual to attend a one-week factory training class. If applicable, costs for travel, lodging and meals will be responsibility of Owner.
  12. Printed training material provided by Contractor to training event attendees.

### 3.8 FIELD QUALITY CONTROL

- A. Field Inspection: Coordinate field inspection in accordance with appropriate sections in Division 01.

**\*\* NOTE TO SPECIFIER \*\* Include if manufacturer provides field quality control with onsite personnel for instruction or supervision of product installation, application, erection or construction. Delete if not required.**

- B. Manufacturer's Services: Coordinate manufacturer's services in accordance with appropriate sections in Division 01.

### 3.9 CLEANING AND PROTECTION

- A. Clean and protect products in accordance with the manufacturer's recommendations.
- B. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION