SECTION 23 09 23
DIRECT DIGITAL CONTROL SYSTEM FOR HVAC (Optimizer Suite)

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PART 1 GENERAL

1.1 SECTION INCLUDES

A. Building Management System (BMS), utilizing direct digital controls. (Optimizer Suite)

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Products Supplied but Not Installed Under This Section:
1. Control valves.
2. Flow switches.
3. Wells, sockets, and other 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. (This does not include VFDs integral to machinery such as chillers or boilers).
8. In-line meters (gas, water, power).
9. Refrigerant monitors.

B. Products Installed but Not Supplied Under This Section:
1. None.

C. Products Not Furnished or Installed but Integrated with the Work of This Section:
1. OEM Chiller control systems.
2. OEM Boiler control systems.
3. OEM Pump control packages.
4. Chemical water treatment.
5. Smoke detectors (through alarm relay contacts).
6. Lighting Control.

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. Power wiring to line side of Electric sub-meters.
3. Installation of In-line meters (gas, water, power).
4. Provision and wiring of smoke detectors and other devices relating to fire alarm systems.
5. Campus LAN (Ethernet) connection adjacent to Advanced Controller network management.

1.3 RELATED SECTIONS

A. Section 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

1.4 REFERENCES

A. American Society of Heating, Refrigeration, 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. Canadian Standards Association (CSA)
1. CAN/CSA C22.2 No. 205: Signal Equipment - Consumer and Commercial Equipment

C. International Electrotechnical Commission (IEC)
1. ISO 9001, "International Organization for Standardization"

D. International Organization for Standardization (ISO)
1. ISO 9001, "Quality Management Systems - Requirements"

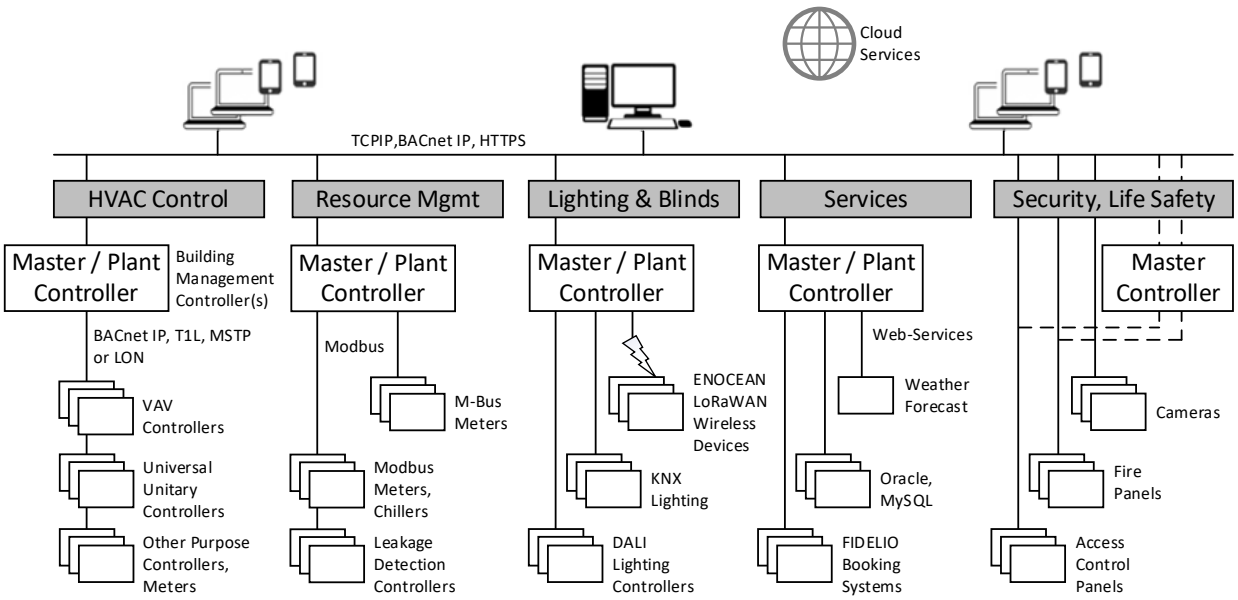
E. Underwriters Laboratories, Inc. (UL)
1. UL 916, "Energy Management"

1.5 SYSTEM DESCRIPTION

A. System Architecture

**** The below system architecture is an example only.**

**** Insert system architecture and riser diagrams as per project needs.**



B. Scope: Furnish all labor, materials, and equipment necessary for a complete and operating Building Management System (BMS), utilizing Direct Digital Controls as shown on the drawings and as described herein. Drawings are diagrammatic only. All controllers furnished in this section shall communicate on a peer-to-peer bus over an open protocol bus

(Examples: BACnet®, LonTalk, Modbus) or IP Network.

1. The intent of this specification is to provide a system that is consistent with BMS systems throughout the owner's facilities running the Niagara 4 Framework®.
2. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, BACnet®, LonTalk, KNX, and Modbus.
3. System shall be capable of data export via native MQTT.
4. System architecture shall provide secure Web access using any of the current versions of Microsoft Internet Explorer, Mozilla Firefox, or Google Chrome browsers from any computer on the owner's LAN.
5. All control devices furnished with this Section shall be programmable directly from the Niagara 4 Workbench embedded toolset. The use of configurable or programmable controllers that require additional software tools for initial/ post-installation maintenance shall not be acceptable.
6. Any control vendor that shall provide additional BMS server software shall be unacceptable. Only systems that utilize the Niagara 4 Framework® shall satisfy the requirements of this section.
7. The BMS server shall host all graphic files for the control system. All graphics and navigation schemes for this project shall match those that are on the existing campus Niagara 4 Framework® server, unless written request for upgrades is received from engineer.
8. A laptop computer including engineering/programming software to modify Operating System Server BMS programs and graphics is optional if all engineering/programming software tools and backups are embedded in the system.
9. Owner shall receive **all** Administrator level login and passwords for engineering toolset at first training session. The Owner shall have full licensing and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the BMS.
10. OPEN NIC STATEMENTS - All Niagara 4 software licenses shall have the following NiCS: "accept.station.in=*"; "accept.station.out=*"and "accept.wb.in=*"and "accept.wb.out=*". All open NIC statements shall follow Niagara Open NIC specifications.
11. All Niagara portability hardware licenses and certificates shall utilize crypto chip and onboard memory for “secure boot”.

C. All products of the BMS shall be provided with the following agency approvals. Verification that the approvals exist for all submitted products shall be provided on request, with the submittal package. Systems or products not currently offering the following approvals are not acceptable:

1. FIPS 140-2 Level 1 Conformance (Federal Information Processing Standard)
2. Federal Communications Commission (FCC), Rules and Regulations, Volume II -July 1986 Part 15 Class A Radio Frequency Devices.
3. FCC, Part 15, Subpart B, Class B.
4. FCC, Part 15, Subpart C.
5. FCC, Part 15, Subpart J, Class A Computing Devices.
6. UL 504 - Industrial Control Equipment.
7. UL 506 - Specialty Transformers.
8. UL 910 - Test Method for Fire and Smoke Characteristics of Electrical and Optical-Fiber Cables Used in Air-Handling Spaces.
9. UL 916 - Energy Management Systems All.
10. UL 1449 - Transient Voltage Suppression.
11. Standard Test for Flame Propagation Height of Electrical and Optical - Fiber Cables Installed Vertically in Shafts.
12. EIA/ANSI 232-E - Interface Between Data Technical Equipment and Data Circuit Terminal Equipment Employing Serial Binary Data Interchange.

13. EIA 455 - Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices.
14. IEEE C62.41- Surge Voltages in Low-Voltage AC Power Circuits.
15. IEEE 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
    a. NEMA 250 - Enclosures for Electrical Equipment.
16. NEMA ICS 1 - Industrial Controls and Systems.
17. NEMA ST 1 - Specialty Transformers.
18. NCSBC Compliance, Energy: Performance of control system shall meet or surpass the requirements of ASHRAE/IESNA 90.1-1999.
19. CE 61326.
20. C-Tick.
21. cUL.

1.6 SPECIFICATION NOMENCLATURE

A. Acronyms used in this specification are as follows:
1. Actuator: Control device that opens or closes valve or damper in response to control signal.
2. AI: Analog Input.
3. AO: Analog Output.
4. Analog: Continuously variable state, overstated range of values.
5. AUC: Advanced Unitary Controller - Spyder Classic/Stryker/Spyder Model 5.
6. AVC: Advanced VAV Controller – Optimizer VAV.
7. BCT: BACnet® Touchscreen Communicating Thermostat – TC500.
8. BMS: Building Management System.
9. DDC: Direct Digital Control.
10. Discrete: Binary or digital state.
11. DI: Discrete Input.
12. DO: Discrete Output.
13. FC: Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
14. FO: Fail open (position of control device or actuator). Device moves to open position on loss of control signal or energy source.
15. GUI: Graphical User Interface.
16. HMI: Human Machine Interface.
17. HVAC: Heating, Ventilating and Air Conditioning.
18. IDC: Interoperable Digital Controller.
19. ILC: Interoperable Lon Controller.
20. LAN: Local Area Network.
21. Modulating: Movement of a control device through an entire range of values, proportional to an infinitely variable input value.
22. Motorized: Control device with actuator.
23. NAC: Network Area Controller.
24. NC: Normally closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
25. 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.
26. NPICU: Niagara embedded Programmable IP Control Unit CIPer Model 30.
27. OSS: Operating System Server, host for system graphics, alarms, trends, etc.
28. Operator: Same as actuator.
29. PC: Personal Computer.
30. Peer-to-Peer: Mode of communication between controllers in which each device connected to network has equal status and each shares its database values with all other devices connected to network.

31. P: Proportional control; control mode with continuous linear relationship between observed input signal and final controlled output element.
32. 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).
33. PICS: BACnet® Product Interoperability Compliance Statement.
34. PICU: Programmable IP Control Unit - Optimizer Unitary/VAV Controller.
35. 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).
36. Point: Analog or discrete instrument with addressable database value.
37. PPCU: Programmable Plant Control Unit – CIPer Model 50.
38. UICU: Unitary IP Control Unit – CIPer Model 10.
39. UIO: Universal Input Output
40. WAN: Wide Area Network.

1.7 SUBMITTALS

A. Submit under provisions of Section 01 30 00 - Administrative Requirements.

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. Installation methods.

C. Submit documentation of contractor qualifications, including those indicated in "Quality Assurance" if requested by the A-E.

D. One set shop drawings of the entire control system shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers' catalog data sheets and installation instructions. Submit in printed and electronic format. Samples of written Controller Checkout Sheets and Performance Verification Procedures for applications similar in scope shall be included for approval.

E. Shop drawings shall also contain complete wiring and schematic diagrams, sequences of operation, control system bus layout and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.

F. Upon completion of the work, provide a complete set of ' as-built' drawings and other project-specific documentation in 3-ring hard-backed binder and electronically.

G. Any deviations from these specifications or the work indicated on the drawings shall be clearly identified in the Submittals.

1.8 QUALITY ASSURANCE

A. The Control System Contractor shall have a full service DDC office within 50 miles of the job site. It is preferable that **multiple** contractor bids **using the same products, software and programming tools from the same manufacturer** be provided. The office shall be staffed with applications engineers, software engineers and field technicians. This office shall maintain parts inventory and shall have all testing and diagnostic equipment necessary to

support this work, as well as staff trained in the use of this equipment.

B. Single Source Responsibility of Supplier: The Control System Contractor shall be responsible for the complete installation and proper operation of the control system. The Control System Contractor shall exclusively be in the regular and customary business of design, installation, and service of computerized building management systems similar in size and complexity to the system specified. The Control System Contractor shall be the manufacturer of the primary DDC system components or shall have been the authorized representative for the primary DDC components manufacturer for at least 5 years. All control panels shall be provided as assembles by the Control System Contractor produced in a UL-Certified 508A panel shop.

C. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in the production and installation of HVAC control systems. Products shall be the manufacturer's latest standard design and have been tested and proven in actual use.

1.9 PRE-INSTALLATION MEETINGS

A. Convene a pre-installation meeting minimum of two weeks prior to starting work in this section; required attendance by all affected installers, architect, mechanical engineer, and owner or owner’s designated representative.

1.10 DELIVERY, STORAGE AND HANDLING

A. Maintain integrity of shipping cartons for each piece of equipment and control device through shipping, storage and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

1.11 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct, and conduit runs, electrical outlets and fixtures, air diffusers and structural and architectural features.

1.12 SEQUENCING

A. Ensure that products of this section are supplied to affected trades in time to prevent interruption of construction progress.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers MUST be an IEC 62443-4-1 Certified Development Organization.

B. Basis of Design: Honeywell Building Automation, which is located at: 715 Peachtree St. NE, Atlanta, GA 30308; Contact request info (https://buildings.honeywell.com/us/en/brands/our-brands/bms/contact/contact-us); Web: https://buildings.honeywell.com/us/en/brands/our-brands/bms. Only registered Honeywell Controls Integrators (HCI) are acceptable as defined as:
1. Authorized Controls Integrator (ACI Direct, ACI Elite or ACI).
2. Building Control Specialist (BCS).

C. Substitutions: **<Not permitted unless by an IEC 62443-4-1 Certified Development Organization>**.

D. Requests for substitutions will be considered in accordance with the provisions of Section 01 60 00 - Product Requirements.

2.2 GENERAL

A. The Building Management System (BMS) shall be comprised of a network of interoperable, stand-alone digital controllers, network area controller(s), graphics and programming and other control devices for a complete system as specified herein.
The network of interoperable stand-alone digital controllers shall communicate BACnet® IP at a minimum of 10MB speeds.

B. The installed system shall provide Multi-level secure password access to all software features, functions and data contained in the overall BMS.

C. All controllers installed in the BMS shall be manufactured by an IEC 62443-4-1 Certified Development Organization.
1. This ensures the system is manufactured to an ISASecure SDLA (Secure Development Life-cycle Assurance) compliance for industrial automation and control systems and reduces cybersecurity risk.
2. https://isasecure.org/end-users/iec-62443-4-1-certified-development-organizations

2.3 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURE

A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system utilizing Open protocols in one open, interoperable system including Analytics for BMS fault detection and diagnostics, including sub-system alarm suppression as described in ASHRAE Guideline 36-2021.

B. The computer software supplied shall employ object-oriented technology (OOT) for representation of all data and control devices within the system.
Physical connection of any BACnet® control equipment, in new construction shall be via Ethernet or IP communicating at a minimum speed of 10MB. BACnet® MS/TP connection shall be acceptable in retrofit/ upfit projects or devices where IP is not an available option.

C. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.

D. The supplied system shall incorporate the ability to access all data using HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside:
1. On Premise in the Operating System Server located in the Facilities Office on the LAN
2. Off Premise in a Microsoft® Azure cloud supported framework dashboard.
Systems requiring proprietary database and user interface programs shall not be acceptable.

E. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single-tiered architecture shall not be acceptable.
1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
2. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote connected user interfaces.

F. BMS Manufacturer to guarantee Niagara OS version released is fully tested and supported on their controllers using a documented Software Inter-operability Testing plan and present if requested. This shall guarantee end-user is purchasing a system which is fully supported and warrantied by manufacturer.

2.4 BAS SERVER HARDWARE

A. Minimum Computer Configuration (Hardware Independent).
   1. Central Server. Owner shall provide a dedicated BAS server with configuration that includes the following components as a minimum:
   2. Processor: Intel® Xeon® 4th Gen (or better), Intel® Core® i-series 12th Gen (or better), AMD® Ryzen® 5 Gen 3 (or better)
   3. Memory: 16 GB DDR4 minimum, 32 GB or more recommended for larger systems
   4. Hard Drive: SSD 512 GB minimum, more recommended depending on archiving requirements
   5. Network Support: Ethernet adapter (10/100/1000 Mb with RJ-45 connector)
   6. Video: 1080p (1920 x 1080) minimum resolution
   7. Operating System: Windows 11 x64-bit; Windows Server 2025; Linux x64-bit: RedHat Enterprise Linux 9.x, Ubuntu 24.04 LTS
   8. Browser: Chrome, Firefox, Microsoft Edge
   9. Mobile Browser: Safari on iOS, Chrome on Android
   10. Relational Database (optional): MS SQL Server 2022; MySQL Server 9.0
   11. Container Engine (for Containerized Supervisors): Docker, Inc.

2.5 NIAGARA ANALYTICS – GENERAL

A. Provide a fault detection and analytic framework that utilizes a high-performance calculation engine. The engine shall permit real-time data to be combined with historical data using a set of wire and property sheets. The visual programming interface shall be used to define the algorithms (formulas) that analyzes the real-time and trend data collected from the BMS. At a minimum, Analytics for BMS fault detection and diagnostics, including sub-system alarm suppression as described in ASHRAE Guideline 36-2021 shall be provided.

B. The output from the analysis shall be able to be visualized in charts, graphs and dashboards and be used as inputs to standard Niagara logic. Faults shall be prioritized according to the associated system, location, and the level of cost avoidance.

C. When applied to historical and real-time data, the framework algorithms shall provide the following analysis features:
   1. An open and extensible analytical environment that can easily customized.
   2. Analytic tools that apply to any data types available from building sub-systems.
   3. The ability to set-up complex analysis without custom programming.
   4. Support for third party API visualization application programs

2.6 NIAGARA CYBER SECURITY DASHBOARD – GENERAL

A. Implement a Niagara Security Dashboard as a centralized, easy-to-read, and actionable view on the security posture of the entire Niagara infrastructure. The dashboard shall provide visual alerts in the event that any Niagara station in your network is set to allow non-secure connections. It shall display the status of required certificates for each station and shall identify whether running software modules and program objects are signed by their developers. Cyber dashboard shall present all the potential cyber issues at a glance and user shall be able to remediate them quickly for the protection of the Niagara network.

B. The Station View shall show individual services including User Service, Fox Service, Web Service, Login Service, Authentication Service, and Module Permissions. The Supervisor view shall show all devices on the Niagara network, so Niagara users can quickly identify

issues and triage outliers.

C. The Niagara Cyber Security Dashboard shall be implemented on EVERY Supervisor GUI, SNC, JNC, and EVERY IP Controller including PICU, PPCU, and UICU.

2.7 SYSTEM NETWORK CONTROLLER (SNC) – Honeywell Optimizer Suite Advanced Controller

A. These controllers are designed to manage communications between the Niagara embedded JACE Network Controller (JNC), Programmable IP Control Units (PICU), Programmable Plant Control Units (PPCU), Unitary IP Control Unit (UICU), and non-Niagara embedded Programmable IP Control Unit (NPICU), Advanced Unitary Controllers (AUC), Advanced VAV Controller (AVC), BACnet® Touchscreen Communicating Thermostats (BCT), and BACnet® Touchscreen Communicating Fan Coil Thermostats (FCT) which are connected to its communications trunks or directly on the IP network, manage communications between itself and other system network controllers (SNC), JNCs, NPICUs, PICUs, PPCUs, UICUs, NPICUs, AUCs, AVCs, BCTs, FCTs, and with any operator workstations (OWS) that are part of the BAS, whether the OWS is directly connected or connected via the Internet, and perform control and operating strategies for the system based on information from any controller connected to the BAS.

B. The SNC shall be an IEC 62443-4-2-SL2 Certified Component.

C. The controllers shall be fully programmable to meet the unique requirements of the facility it shall control, including Analytic calculations.

D. The communication protocols utilized for peer-to-peer communications between SNCs, JNCs, PICUs, PPCUs, and UICUs will be Niagara 4 FoxS, BACnet® TCP/IP and SNMP. Use of a proprietary communication protocol for peer-to-peer communications between SNCs, JNCs, PICUs, PPCUs, and UICUs is not allowed.

E. The SNC shall employ a device and point count capacity license model that supports expansion capabilities.

F. The SNC shall be enabled to support and shall be licensed with the following Open protocol drivers (client and server) by default:
1. BACnet®
2. BACnet® /SC (when running Niagara N4.12u2 or higher)
3. Lon
4. MODBUS
5. Data export via native MQTT

G. The SNC shall have a backup and restore function utilizing available USB-C port without the need of software engineering workbench.

H. The SNC shall be capable of executing application control programs to provide:
1. Calendar functions.
2. Scheduling.
3. Trending.
4. Alarm monitoring and routing.
5. Time synchronization.
6. Integration of BACnet®, LonWorks, and Modbus controller data.
7. Network management functions for all SNC, JNC, PICU, PPCU, UICU, NPICU, AUC, AVC, and BCT based devices.
8. Analytics for BMS fault detection and diagnostics, including sub-system alarm suppression as described in ASHRAE Guideline 36-2021.

I. The SNC shall provide the following hardware features as a minimum:

1. A minimum of two (2) and up to four (4) 10/100/1000 Mbps Ethernet ports. An isolated port and one (1) or three (3) managed switch ports for OT network.
    a. Allowing for IT control of switch as part of OT network
2. From two (2) to four (4) Isolated RS-485 ports with terminator switches built to SNC. Add-on communication modules to meet the requirement shall not be allowed.
3. 768 KB Ferroelectric RAM (FRAM).
4. 2 GB Low Power Double Data Rate RAM (LPDDR4).
5. 8 GB Embedded Multi-Media Card (EMMC).
6. i.MX 8M Plus, quad Arm® Cortex®-A53 processor, 1.2 GHz.
7. Real-Time Clock Timekeeping
8. High Speed Field Bus Expansion supporting a minimum of 64 IO Modules on single bus, limited to maximum of 16 of each type of 16 IO Module, with a maximum of 896 IO points.
9. Panel Bus Scan Time shall not exceed 1 second when fully loaded IO modules
10. RJ11 Interface to connect with an HMI device for field operations.
11. -13 degrees to 140 degrees F (-25 degrees to 60 degrees C) Ambient Operating Temperature.
12. Integrated 24 VAC / DC Global Power Supply.

J. The following DIN rail mountable Expansion IO Module types shall be supported per each SNC, limited to a maximum if sixteen [16] of each TYPE:
    1. 4 Digital Outputs
    2. 4 Digital Outputs with HOA
    3. 8 Digital Outputs
    4. 8 Digital Outputs with HOA
    5. 8 Digital Inputs
    6. 16 Digital Inputs
    7. 8 Analog Outputs
    8. 8 Analog Outputs with HOA
    9. 16 Universal Inputs
    10. 4 Universal Inputs/Outputs
    11. 4 Universal Inputs/Outputs with HOA
    12. 8 Universal Inputs/Outputs
    13. 8 Universal Inputs/Outputs with HOA
    14. 16 Universal Inputs/Outputs
    15. 16 Universal Inputs/Outputs with HOA
    16. Power and Communication Bus shall be transferred to the Expansion IO Modules by Touchflake connections enabling quick installation.
    17. A Wiring Adapter shall be available to extend Power and Communication Bus to a separate DIN rail of Expansion IO Modules.
    18. Analog Inputs shall be 16 Bit resolution (Software configurable as a Voltage, Current or Thermistor Input).
        a. Voltage Input: 0-10Vdc, 2-10Vdc (Direct/Reverse).
            1) Custom characteristic available in the tool.
            2) Minimum resolution of 0.01 volts.
            3) ± 0.4% of FSR (Full Scale Range).
        b. Current Input: 0-20mA, 4-20mA, 0-10mA, 4-10mA (Direct/Reverse).
            1) Custom characteristic available in the tool.
            2) ± 0.5% of FSR (Full Scale Range).
        c. Accuracy: 0-80 ohm, 0.5%, ± 0.5 ohm.
        d. Thermistor Input: 0-1M ohm.
            1) Custom characteristic available in the tool.
            2) <= 1% of accuracy.
    19. Operating Voltage: 19–29 Vac (50/60Hz) or 19-29 Vdc.
        a. Protected against overvoltages of max. 29 Vac or 40 Vdc.
        b. Terminals protected against short-circuiting.

20. Ambient Operating Temperature: -40 to 150 °F (-40 to 65.5 °C) for non-HOA variants, Wiring Adapter, and Auxiliary terminal block.
    -4 to 150 °F (-20 to 65.5 °C) for HOA variants.
21. Ambient Operating Humidity: 5 to 95% RH (non-condensing).
22. LED for each hardware I/O point (Off, Green, Yellow, Red).
23. Shall include Service LED, RS485 LED, Ring LED, Service reset button, Auto Button (HOA Modules only), Rotary Dial (HOA Modules only).

K. The SNC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.

L. The SNC shall provide alarm recognition, storage, routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.

M. The SNC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote.
1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:
    a. Alarm.
    b. Return to normal.
    c. To default.
2. Alarms shall be annunciated in any of the following manners as defined by the user:
    a. Screen message text.
    b. Email of complete alarm message to multiple recipients.
    c. Graphics with flashing alarm object(s).
3. The following shall be recorded by the SNC for each alarm (at a minimum):
    a. Time and date.
    b. Equipment (air handler #, access way, etc.).
    c. Acknowledge time, date, and user who issued acknowledgement.

N. Programming software and all controller "Setup Wizards" shall be embedded into the SNC. Engineering tools that are required to “tunnel” shall not be allowed.

O. The SNC shall support the following security functions:
1. Module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted.
2. IEEE Standard 802.1X port-based network access control (when running Niagara N4.12u2 or higher).
3. Role-Based Access Control (RBAC) for managing user roles and permissions.
4. Require users to use strong credentials.
5. Data in Motion and Sensitive Data at Rest be encrypted.
6. LDAP and Kerberos integration of access management.

P. The SNC shall support the following data modeling structures to utilize Search; Hierarchy; Template; and Permission functionality:
1. Metadata: Descriptive tags to define the structure of properties.
2. Tagging: Process to apply metadata to components.
3. Tag Dictionary.

Q. The SNC shall employ template functionality. Templates are a containerized set of configured data tags, graphics, histories, alarms... that are set to be deployed as a unit based upon manufacturer's controller and relationships. All lower level communicating controllers (PICU, PPCU, UICU, NPICU, AUC, AVC, BCT) shall have an associated template file for reuse on future project additions.

R. The SNC shall be provided with a 5 Year Hardware Warranty and a 5 Year Software Maintenance license. Labor to implement upgrades during the 5-year SMA period not

included.

2.8 JACE NETWORK CONTROLLER (JNC) – HON-9000

A. These controllers are designed to manage communications between the Niagara embedded System Network Controller (SNC), Programmable IP Control Units (PICU), Programmable Plant Control Units (PPCU), Unitary IP Control Unit (UICU), and non-Niagara embedded Programmable IP Control Unit (NPICU), Advanced Unitary Controllers (AUC), Advanced VAV Controller (AVC), and BACnet® Touchscreen Communication Thermostats (BCT) which are connected to its communications trunks or directly on the IP network, manage communications between itself and other JACE network controllers (JNC), SNCs, PICUs, PPCUs, UICUs, NPICUs, AUCs, AVCs, BCTs, and with any operator workstations (OWS) that are part of the BAS, whether the OWS is directly connected or connected via the Internet, and perform control and operating strategies for the system based on information from any controller connected to the BAS.

B. The controllers shall be fully programmable to meet the unique requirements of the facility it shall control, including Analytic calculations.

C. The communication protocols utilized for peer-to-peer communications between JNCs, SNCs, PICUs, PPCUs, and UICUs will be Niagara 4 FoxS, BACnet® TCP/IP and SNMP. Use of a proprietary communication protocol for peer-to-peer communications between, JNCs, SNCs, PICUs, PPCUs, and UICUs is not allowed.

D. The JNC shall employ a device count capacity license model that supports expansion capabilities.

E. The JNC shall be enabled to support and shall be licensed with the following Open protocol drivers (client and server) by default:
   1. BACnet®
   2. BACnet®/SC (when running Niagara N4.12u2 or higher)
   3. Lon
   4. MODBUS
   5. Data export via native MQTT

F. The JNC shall be capable of executing application control programs to provide:
   1. Calendar functions.
   2. Scheduling.
   3. Trending.
   4. Alarm monitoring and routing.
   5. Time synchronization.
   6. Integration of LonWorks, BACnet®, and MODBUS controller data.
   7. Network management functions for all JNC, SNC, PICU, PPCU, UICU, NPICU, AUC, AVC, and BCT based devices.
   8. Analytics for BMS fault detection and diagnostics, including sub-system alarm suppression as described in ASHRAE Guideline 36-2018.

G. The JNC shall provide the following hardware features as a minimum:
   1. Two 10/100/1000 Mbps Ethernet ports.
   2. Two Isolated RS-485 ports with biasing switches.
   3. 2 GB Low Power Double Data Rate RAM (LPDDR4).
   4. 8 GB Removable micro-SD card.
   5. i.MX 8M Plus, quad Arm® Cortex®-A53 processor, 1.2 GHz.
   6. Real-Time Clock Timekeeping
   7. Wi-Fi (Client or WAP) – only available for wireless model
      a. Wi-Fi (802.11ac)
      b. 1x1 802.11 a/b/g/n/ac

c. Configurable radio (Off, WAP, or Client)
d. WPAPSK/WPA2PSK supported
8. Integrated 24 VAC/DC Global Power Supply
9. Battery less
10. Secure boot
11. -4 degrees to 140 degrees F (-20 degrees to 60 degrees C) Ambient Operating Temperature
12. Integrated 24 VAC / DC Global Power Supply

H. The JNC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.

I. The JNC shall provide alarm recognition, storage, routing, management and analysis to supplement distributed capabilities of equipment or application specific controllers.

J. The JNC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via cellular modem, or wide-area network.
1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:
a. Alarm.
b. Return to normal.
c. To default.
2. Alarms shall be annunciated in any of the following manners as defined by the user:
a. Screen message text.
b. Email of complete alarm message to multiple recipients.
c. Pagers via paging services that initiate a page on receipt of email message.
d. Graphics with flashing alarm object(s).
3. The following shall be recorded by the SNC for each alarm (at a minimum):
a. Time and date.
b. Equipment (air handler #, access way, etc.).
c. Acknowledge time, date, and user who issued acknowledgement.

K. Programming software and all controller "Setup Wizards" shall be embedded into the JNC.

L. The JNC shall support the following security functions.
1. Module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted.
2. Role-Based Access Control (RBAC) for managing user roles and permissions.
3. Require users to use strong credentials.
4. Data in Motion and Sensitive Data at Rest be encrypted.
5. LDAP and Kerberos integration of access management.

M. The JNC shall support the following data modeling structures to utilize Search; Hierarchy; Template; and Permission functionality:
1. Metadata: Descriptive tags to define the structure of properties.
2. Tagging: Process to apply metadata to components
3. Tag Dictionary

N. The JNC shall employ template functionality. Templates are a containerized set of configured data tags, graphics, histories, alarms... that are set to be deployed as a unit based upon manufacturer's controller and relationships. All lower level communicating controllers (PICU, PPCU, UICU, NPICU, AUC, AVC, BCT) shall have an associated template file for reuse on future project additions.

O. The JNC shall be provided with an 18-month Hardware Warranty and a 5 Year Software Maintenance license. Labor to implement upgrades during the 5-year SMA period not included.

2.9 PROGRAMMABLE IP CONTROL UNIT (PICU) – Honeywell Optimizer Unitary/VAV Controller

A. HVAC PICU controllers shall be fully programmable to meet the unique requirements of the facility it shall control. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework®, that allow standard and customizable control solutions required in executing the "Sequence of Operation". PICU shall be BACnet® BTL, WSP listed. PICU shall meet the BACnet® Advanced Application Controller (B-AAC) or Building Controller (B-BC) Profile.

B. All PICUs shall be application programmable and shall always maintain their certification. All control sequences within or programmed into the PICU shall be stored in non-volatile memory, controllers with batteries shall not be allowed. This is to reduce long term maintenance costs for the owner associated with battery replacement.

C. PICU's shall be capable of daisy-chain IP communications with other PICU's and peer-to-peer communications with SNC's and with any controllers connected to the BAS.
   1. Controller must include the ability to disable physical ethernet ports not in use.
   2. Controller must include the ability to display link speed of each physical ethernet port.
   3. Controller must include the ability to display port diagnostics for each physical ethernet port.
   4. Controller shall support IP through RJ45 ethernet cabling or 10BASE-T1L twisted pair media and can utilize existing communication bus so long as it meets minimum specifications for T1L communication protocol method.

D. If PICU's are networked with Cat5e or Cat6 cable, a maximum length of 328 feet (100 meters) between controllers shall be allowed.

E. If PICU's are networked utilizing 10BASE-T1L single pair media, a maximum length of 984 feet (300 meters) between controllers when wired in fault-tolerant daisy chain shall be allowed. Or a maximum of 2,952 feet (900 meters) between controllers, when wired without fault-tolerant daisy chain shall be allowed.
   1. 10BASE-T1L communication wire shall meet the following requirements:
      a. Balanced single twisted-pair copper cable
      b. Nominal impedance of 100 Ω (range 80 Ω - 120 Ω)
      c. Shielded or unshielded
      d. 18AWG to 24AWG
      e. Belden 74040NH, Belden 9841NH, or equivalent

F. The communication protocols utilized for peer-to-peer communications between PICU's will be BACnet® TCP/IP. Use of a proprietary communication protocol for peer-to-peer communications between PICU's is not allowed.

G. The PICU shall be enabled to support the following Open protocol drivers by default:
   1. BACnet® IP or BACnet® T1L
   2. BACnet® MS/TP
   3. MODBUS RTU Client
   4. DALI
   5. Sylk™ Bus

H. The minimum controller Environmental ratings:
   1. Unitary Operating Temperature Ambient Rating: -40 degrees to 122 degrees F (-40 degrees to 50 degrees C).
   2. VAV Operating Temperature Ambient Rating: 32 degrees to 122 degrees F (0 degrees to 50 degrees C) in a conditioned space.
   3. Storage Temperature Ambient Rating: -40 degrees to 150 degrees F (-40 degrees to 65 degrees C).
   4. Relative Humidity: 5 % to 95 % non-condensing.

I. The controller shall have the additional approval requirements, listings, and approvals:
   1. UL 916
   2. UL 60730-1 (Unitary)
   3. FCC Part 15, Class A (VAV)
   4. FCC Part 15, Subpart B, Class B (radiated emissions) requirements (Unitary)
   5. EN 55022 Class A (VAV)
   6. EN 61000-3-2, 61000
   7. UL 2043

J. The PICU shall provide the following hardware features as a minimum:
   1. N4 Engineering software and all controller programming tools shall be utilized to upload and download to the controller using active function-block programming. Engineering tools that are required to “tunnel” through SNC shall not be allowed.
   2. The PICU shall provide LED indication of Power, Fault, Ethernet TX/RX/Traffic/Speed without cover removal.
   3. Two (2) 10/100 Mbps Ethernet managed switch, RJ-45 ports that support RTSP
   4. NXP I.MRT Cortex M7 Crossover Processor
   5. 16 MB SDRAM.
   6. 16 MB QSPI Flash Memory.
   7. Integrated 20-30 VAC, 24-30 VDC Global Power Supply.
   8. Power Output: 1 x 24 VAC at 75mA, 1 x 24 VDC at 75mA (VAV), 3 x 24 VDC at 75mA (Unitary)
   9. AC power consumption at 8 VA, max 30 VA (Unitary)
   10. Color Coded Removable Terminal Blocks.
   11. VAV PICU shall include an internal differential pressure sensor.
      a. Operating Range: -2.0 inch to +2 inch WC (-500 to +500 Pa Bi-Directional).
      b. Accuracy: +/- 3 % of full scale at 32 degrees to 122 degrees F (0 degrees to 50 degrees C).
      c. Field Replaceable
   12. VAV PICU shall provide an integrated actuator.
      a. Actuator type: Series Floating with positional feedback.
      b. Rotation stroke: 95 degrees.
      c. Torque rating: 44 lb-inch (5 Nm).
      d. Run time for 90-degree rotation: 90 seconds at 60 Hz.
   13. The following [8 Small or 16 Large Unitary or 7 VAV] integral Universal Inputs/Outputs shall be supported per each PICU:
   14. UI/O as Analog Inputs; 16 Bit resolution (Thermistor or RTD configurable from 100-100 K Ohm, 0-10 VDC, 4-20 mA, 10K Ohm NTC Type II or III, 10K3A1, 20K Ohm NTC, PT100, PT1000, NI1000, PT3000).
   15. UI/O as Digital Inputs; Dry Contact / Totalizer.
      a. Dry Contact to detect Open / Closed Circuit.
      b. Totalizer – Dry Contact (100 Hz, minimum pulse width 5 ms).
   16. UI/O as Analog Outputs
      a. 0-10.0 VDC direct/reverse with -3 mA to +20 mA.
      b. 0-20.0 mA direct/reverse.

K. The following [4 Solid State Relays Small / Large Unitary or 5 VAV] integral Digital Outputs (SSR) shall be supported per each PICU:
   1. Solid State Relay normally open contacts with maximum 24 VAC / VDC at 1.5 A Continuous, 3.5 A Inrush.

L. The following [4 Relays Small / Large Unitary] integral Digital Outputs (Relay) shall be supported per each PICU:
   1. Relay (Normally Open, Normally Closed, Common) with up to 277 VAC / 230 VAC (+20%) 10 A Continuous, 100 A Inrush for 100 ms.

M. PICU Controllers shall support at minimum the following control techniques:
   1. General-purpose control loops that can incorporate Demand Limit Control strategies, set point reset, adaptive intelligent recovery, and time of day bypass.
   2. General-purpose, non-linear control loops.
   3. Start/stop Loops.
   4. If/Then/Else logic loops.
   5. Math Function loops (MIN, MAX, AVG, SUM, SUB, SQRT, MUL, DIV, ENTHALPY).
   6. Analytic calculations.

2.10 PROGRAMMABLE IP CONTROL UNIT (NPICU) – Brand Name: CIPer Model 30

A. HVAC NPICU controllers shall be fully programmable to meet the unique requirements of the facility it shall control. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework®, that allow standard and customizable control solutions required in executing the "Sequence of Operation". NPICU shall be BACnet® BTL; AWS/C, WSP listed. NPICU shall meet the BACnet® Building Controller (B-BC) Profile. Each NPICU shall include the Niagara Security Dashboard.

B. All NPICUs shall be application programmable and shall always maintain their certification. All control sequences within or programmed into the NPICU shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.

C. NPICU's shall be capable of daisy-chain IP communications with other NPICU's and peer-to-peer communications with SNC's and with any OWS connected to the BAS, whether the OWS is directly connected, connected via cellular modem, or connected via the Internet.
   1. Controller must include the ability to disable physical ethernet ports not in use.
   2. Controller must include the ability to display link speed of each physical ethernet port.
   3. Controller must include the ability to display port diagnostics for each physical ethernet port.
   4. Controller must include the ability to perform and display cable diagnostics for the cable connected to each physical ethernet port.

D. NPICU's shall be capable of deployment in an IP ring topology with integrated fail-safe utilizing Rapid Spanning Tree Protocol (RSTP) 802.1w. RSTP must be able to accommodate up to 39 controllers.

E. NPICU's shall be networked with Cat 5e or Cat6 cable at a maximum length of 100 meters between controllers.

F. The communication protocols utilized for peer-to-peer communications between NPICU's will be Niagara 4 FoxS or BACnet® TCP/IP. Use of a proprietary communication protocol for peer-to-peer communications between NPICU's is not allowed.

G. The NPICU shall be licensed and enabled to support three (3) devices and shall be licensed with the following Open protocol drivers by default:
   1. BACnet® IP

H. The NPICU shall be provided with Software Maintenance license for the life of Niagara 4. Labor to implement not included.

I. The NPICU shall be capable of executing application control programs to provide:
   1. Calendar functions.
   2. Scheduling.
   3. Trending.
   4. Alarm monitoring and routing.
   5. Time synchronization.
   6. Integration of all daisy-chain NPICU's.

7. Network management functions for all daisy-chain NPICU's.
8. Analytics for BMS fault detection and diagnostics, including sub-system alarm suppression as described in ASHRAE Guideline 36-2018.
9. 10 Niagara N4 Analytic Points.

J. Programming software shall be embedded into the NPICU. The NPICU shall not require any external configuration tool or programming tool. All configuration and programming tasks shall be accomplished and accessible from within the embedded Niagara 4 environment.

K. The NPICU shall support the following security functions.
1. Module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted.
2. Role-Based Access Control (RBAC) for managing user roles and permissions.
3. Require users to use strong credentials.
4. Data in Motion and Sensitive Data at Rest be encrypted.
5. Encrypted (PKI) Secure IP Stack Communication Security.
6. Supports TLS version 1.2.
7. FIPS 140-2 Level 1 Cryptographic Module Compliant.
8. Integrated firewall that closes all software ports that are not explicitly defined.
9. Support the ability to enable or disable each IP Switch Port.
10. Support the ability to restrict access to each IP Switch Port via listed device MAC address, i.e., provide MAC address filtering at each IP Switch Port.
11. Display the link speed of each IP Switch Port.
12. Display the cable diagnostics status for each IP Switch Port.
13. Display the port diagnostics information for each IP Switch Port.

L. The minimum controller Environmental ratings.
1. Operating Temperature Ambient Rating: -4 degrees to 131 degrees F (-20 degrees to 55 degrees C).
2. Storage Temperature Ambient Rating: -4 degrees to 150 degrees F (-20 degrees to 65 degrees C).
3. Relative Humidity: 5 % to 95 % non-condensing

M. The controller shall have the additional approval requirements, listings, and approvals:
1. UL 60730-1.
2. Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.
3. Conforms requirements European Consortium standard EN 61000-6-1; 2001 (EU Immunity).
4. Conforms requirements European Consortium standard EN 61000-6-3; 2001 (EU Emission).
5. The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (2.3" x 5.3" x 4.3"; 57.4 mm x 135 mm x 110 mm).

N. The NPICU shall provide the following hardware features as a minimum:
1. The NPICU shall provide LED indication of Power, Fault, Ethernet TX/RX/Traffic/Speed without cover removal.
2. Four 10/100/1000 Mbps Ethernet managed switch, RJ-45 ports.
3. ARM 9 32-bit processor, 800 MHz
4. 1 GB RAM
5. 512 KB MRAM
6. 2 GB Flash Memory
7. The NPICU shall have two microprocessors. The Host processor contains on-chip FLASH program memory, FLASH information memory, and RAM to run the main HVAC application. The second processor for network communications.
8. One USB 2.0 port.
9. 2.0 A fast-acting Overcurrent Protection.
10. Integrated 20-30 VAC Global Power Supply

11. Real Time Clock, 24-hour, 365-day, multi-year calendar +/- 1 minute per month at 77F (25C).
12. RTC Power Failure Backup, 24 hours at 32 degrees to 100 degrees F (0 degrees to 38 degrees C)
13. Power Output: 20 VDC +/- 10 % at 7 mA maximum.
14. AC power consumption at 9 VA, max 100 VA.
15. Removable Terminal Blocks.
16. Sensor, Actuator, and I/O Module Expandability via a 2-wire, polarity insensitive local NPICU communication bus.
17. LED for each hardware I/O point.
18. Output H-O-A Switches.
19. VAV NPICU shall include an internal differential pressure sensor.
    a. Operating Range: 0-to-2-inch WC (0 to 374 Pa).
    b. Accuracy: +/- 2 % of full scale at 32 degrees to 122 degrees F (0 degrees to 50 degrees C).

O. The NPICU shall support standard Web browser access via the Intranet/Internet.

P. The NPICU shall be able to route any alarm condition to any defined user location whether connected to a local network or wide-area network.
1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:
    a. Alarm.
    b. Return to normal.
    c. To default.
2. Alarms shall be annunciated in any of the following manners as defined by m the user:
    a. Screen message text.
    b. Email of complete alarm message to multiple recipients.
    c. Pagers via paging services that initiate a page on receipt of email message.
    d. Graphics with flashing alarm object(s).
3. The following shall be recorded by the NPICU for each alarm (at a minimum):
    a. Time and date.
    b. Equipment (air handler #, access way, etc.).
    c. Acknowledge time, date, and user who issued acknowledgement.

Q. NPICU Controllers shall support at minimum the following control techniques:
1. General-purpose control loops that can incorporate Demand Limit Control strategies, set point reset, adaptive intelligent recovery, and time of day bypass.
2. General-purpose, non-linear control loops.
3. Start/stop Loops.
4. If/Then/Else logic loops.
5. Math Function loops (MIN, MAX, AVG, SUM, SUB, SQRT, MUL, DIV, ENTHALPY).
6. Analytic calculations.

R. The following six [6] integral Universal Inputs/Outputs shall be supported per each NPICU:
1. UI/O as Analog Inputs; 16 Bit resolution (Thermistor or RTD configurable from 100 to 100 K Ohm, 0-10 VDC, 4-20 mA).
2. UI/O as Digital Inputs; Dry Contact / Totalizer.
    a. Dry Contact to detect Open / Closed Circuit (Voltage Rating; 0-30 VDC Open Circuit: Resistance Rating; Open Circuit >3,000 Ohms, Closed Circuit <500 Ohms).
    b. Totalizer – Dry Contact (100 Hz, 360,000 pulses per hour maximum frequency: Minimum Duty Cycle 5 ms ON / 5 ms OFF).
3. UI/O as Analog Outputs ([3] UI/O can be configured as AO)
    a. 0-10.0 VDC, 10.0 mA maximum.

b. 0-20.0 mA, 550 Ohms maximum.

4. LED for each hardware I/O point.

S. The following six [6] integral Digital Outputs (Triac) shall be supported per each NPICU:

1. Solid State Relay normally open contacts, 20-30 VAC @ 50/60 Hz, at 1.0 A Continuous, 3.5 A Inrush.
2. LED for each hardware I/O point.
3. Output H-O-A Switches.

T. The NPICU shall employ a 150 Point Base License device count capacity license model that supports I/O expansion capabilities.

U. Each NPICU shall have expansion ability to support additional I/O requirements through the use of remote input/output modules and a local communication bus. Each Unitary NPICU shall be able to support a maximum of 8 Expansion I/O Modules for a maximum of 172 physical I/O points.

1. Mixed Expansion I/O Modules (UI/O & DO) shall communicate with NPICU via a 2-wire bus and include removable terminals for field device wires.
2. Mixed Expansion I/O Modules shall be available in the following configurations:
   a. 3 UI/O, 2 AO, and 2 DO (7 Points).
   b. 14 UI/O (5 can be configured as AO), and 6 DO (20 Points).
3. Universal Inputs/Outputs shall be supported per each Expansion I/O Module:
   a. UI/O as Analog Inputs; 16 Bit resolution (Thermistor or RTD configurable from 100 to 100 K Ohm, 0-10 VDC, 4-20 mA).
   b. UI/O as Digital Inputs; Dry Contact / Totalizer.
      1) Dry Contact to detect Open / Closed Circuit (Voltage Rating; 0-30 VDC Open Circuit: Resistance Rating; Open Circuit >3,000 Ohms, Closed Circuit <500 Ohms).
      2) Totalizer – Dry Contact (100 Hz, 360,000 pulses per hour maximum frequency: Minimum Duty Cycle 5 ms ON / 5 ms OFF).
   c. UI/O as Analog Outputs (UI/O can be configured as AO)
      1) 0-10.0 VDC, 10.0 mA maximum.
      2) 0-20.0 mA, 550 Ohms maximum.
   d. LED for each hardware I/O point.
4. Digital Outputs (Triac) shall be supported per each Expansion I/O Module:
   a. Solid State Relay normally open contacts, 20-30 VAC @ 50/60 Hz, at 1.0 A Continuous, 3.5 A Inrush.
   b. LED for each hardware I/O point.
   c. Output H-O-A Switches.

V. The NPICU shall not include an integrated Local Operator Interface but shall be capable of utilizing a standard browser-based device such as a Tablet, Touch Screen Device, etc.

2.11 PROGRAMMABLE PLANT CONTROL UNIT (PPCU) – Honeywell CIPer Model 50

A. HVAC PPCU controllers shall be fully programmable to meet the unique requirements of the facility it shall control. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework®, that allow standard and customizable control solutions required in executing the "Sequence of Operation". Each PPCU shall include the Niagara Security Dashboard.

B. PPCU shall meet the BACnet® Building Controller (B-BC) Profile.

C. All PPCUs shall be application programmable and shall always maintain their certification. All control sequences within or programmed into the PPCU shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.

D. The PPCUs shall be capable of daisy-chain IP communications with other PPCU's and peer-to-peer communications with SNC's and with any OWS connected to the BAS, whether the OWS is directly connected, connected via cellular modem, or connected via the Internet.

E. The communication protocols utilized for peer-to-peer communications between PPCU's will be Niagara 4 FoxS or BACnet® TCP/IP. Use of a proprietary communication protocol for peer-to-peer communications between PPCU's is not allowed.

F. The PPCU shall be licensed and enabled to support four (4) devices, expandable to forty-nine [49] and shall be licensed with the PRO following Open protocol drivers by default:
1. BACnet® (MS/TP and IP [ISO 16484-5]).
2. LonTalk (ISO 14908).
3. Modbus (RTU and TCP).

G. The PPCU shall be provided with a Base license utilizing a lifetime "Edge" structure. License can be upgraded to additional functionality and shall include a 5 Year Software Maintenance license if executed.

H. The PPCU shall provide LED indication of communication and controller performance to the technician, without cover removal.

I. The PPCU shall be capable of executing application control programs to provide:
1. Calendar functions.
2. Scheduling.
3. Trending.
4. Alarm monitoring and routing.
5. Time synchronization.
6. Integration of all daisy-chain PPCU's.
7. Network management functions for all daisy-chain PPCU's.
8. Analytics for BMS fault detection and diagnostics, including sub-system alarm suppression as described in ASHRAE Guideline 36-2021.

J. Programming software shall be embedded into the PPCU. The PPCU shall not require any external configuration tool or programming tool. All configuration and programming tasks shall be accomplished and accessible from within the embedded Niagara 4 environment.

K. The PPCU shall support the following security functions:
1. Module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted.
2. Role-Based Access Control (RBAC) for managing user roles and permissions.
3. Require users to use strong credentials.
4. Data in Motion and Sensitive Data at Rest be encrypted.

L. The PPCU shall provide the following hardware features as a minimum:
1. Two10/100 Mbps Ethernet ports.
2. Two RS-485 ports, one isolated and one non-isolated, with biasing switches.
3. ARM 9 32-bit processor, 1 GHz.
4. 1 GB RAM.
5. 512 KB MRAM.
6. 4 GB Flash Memory.
7. Two USB 2.0 ports.
8. One HMI port to connect onboard or remote HMI.
9. 0 degrees to 122 degrees F (0 degrees to 50 degrees C) Ambient Operating Temperature.
10. Integrated 24 VAC / DC Global Power Supply.
11. Real Time Clock.

M. The PPCU shall support standard Web browser access via the Intranet/Internet.

N. The PPCU shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via cellular modem, or wide-area network.
   1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:
      a. Alarm.
      b. Return to normal.
      c. To default.
   2. Alarms shall be annunciated in any of the following manners as defined by the user:
      a. Screen message text.
      b. Email of complete alarm message to multiple recipients.
      c. Pagers via paging services that initiate a page on receipt of email message.
      d. Graphics with flashing alarm object(s).
   3. The following shall be recorded by the PPCU for each alarm (at a minimum):
      a. Time and date.
      b. Equipment (air handler #, access way, etc.).
      c. Acknowledge time, date, and user who issued acknowledgement.

O. PPCU Controllers shall support at minimum the following control techniques:
   1. General-purpose control loops that can incorporate Demand Limit Control strategies, set point reset, adaptive intelligent recovery, and time of day bypass.
   2. General-purpose, non-linear control loops.
   3. Start / stop Loops.
   4. If / Then / Else logic loops.
   5. Math Function loops (MIN, MAX, AVG, SUM, SUB, SQRT, MUL, DIV, ENTHALPY).
   6. Analytic calculations.

P. The following twenty-six [26] integral Inputs/Outputs shall be supported per each PPCU:
   1. Six integral 12 Bit resolution Universal Inputs (configurable as 20K NTC, 10K NTC, 0/2-10 V, 0/4-20 mA, 0.4 Hz Dry Contact).
   2. Four integral dry contact / totalizer Digital Inputs. Totalizer: 15 Hz (25 ms on, 25 ms off, 5 ms bounce).
   3. Four integral 8 Bit 0-10 VDC Analog Outputs with configurable safety position selections.
   4. Eight integral Digital Outputs.
      a. Four Relay normally open contact at 3 A, 250 VAC, 30 VDC.
      b. One Relay normally open contact at 10 A, 250 VAC, 30 VDC with configurable safety position selections.
      c. Three Relay normally open contact with common feed at 3 A, 250 VAC, 30 VDC with configurable safety position selections.

Q. The PPCU shall employ a device count capacity license model that supports I/O expansion capabilities.

R. Each PPCU shall have expansion ability to support additional I/O requirements through the use of remote input/output modules and a local communication bus. Each PPCU shall be able to support a maximum of 2,000+ physical I/O points.
   1. I/O-specific modules (UI, BI, AO, BO) shall require a Terminal Socket Module that includes screw or push-in terminals for field device wires, communication, and port to accept pluggable I/O-specific Module. I/O-specific Modules shall be hot pluggable and shall be replaceable without rewiring.
   2. Remote Universal Input Module (8 UI).
      a. Eight Universal Inputs; 0/2-10 V, 0/4-20 mA, 20 K NTC, 10 K NTC, PT1000-1, PT1000-2, NI1000TK5000, PT3000, BALCO500, Binary Input (0 / 10 V with pull-up).
   3. Remote Binary Input Module (12 BI).

a. Twelve Binary Inputs; Dry contact or Totalizer (20 Hz).
b. Each Binary Input shall include a configurable status LED (Alarm: red/green; Status: yellow/off).

4. Remote Analog Output Module (8 AO).
   a. Eight Analog Outputs with configurable safety position selections. 8 Bit Analog Outputs; 0-10 V, Floating Actuator, Binary Output (0 V / 10 V).
   b. Each Analog Output shall include a RED status LED that varies brightness based on signal level & flashes in override mode (with manual override Module).
   c. Optional version with manual override potentiometer per output.
5. Remote Relay Output Module (6 BO).
   a. Six Relay Outputs with configurable safety position selections.
   b. Each Relay Output shall include a yellow status LED.
   c. Optional version with manual override switch per output (Auto, 0, 1).
6. Remote Floating Output Module (3 FO).
   a. Three Floating Outputs with configurable safety position selections. 2 Relays per Floating Output.
   b. Each Floating Output shall include a RED status LED (opening) and a GREEN status LED (closing).
   c. Manual override potentiometer per output.
7. Remote Mixed I/O Module (8 UI, 12 BI, 8 AO, 6 BO).
   a. Eight Universal Inputs; 0/2-10 V, 20 K NTC, Binary Input (dry contact).
   b. Twelve Binary Inputs; Dry contact or Totalizer (15 Hz).
      1) Each Binary Input shall include a yellow status LED.
   c. Eight Analog Outputs with configurable safety position selections. 10 Bit Analog Outputs; 0-10 V, Binary Output (0 V / 10 V).
   d. Six Relay Outputs.
      1) Each Relay Output shall include a yellow status LED.

S. The PPCU shall be provided with an integrated Local Operator Interface.
1. Local Operator Interface shall allow User-ID and password protected access.
2. Local Operator Interface shall provide a backlit display, with automatic backlight time-out.
   a. The display backlight shall automatically light upon press of a key or operation of the push & turn wheel. The display backlight will extinguish if operating keys or push & turn wheel is not used for two minutes.
3. Local Operator Interface shall provide a full display of long text information.
   a. Automatic left and right scrolling shall ensure that text information longer than the display width can be viewed.
4. Local Operator Interface shall provide configurable screens for viewing and adjusting data points and parameters, including the following operations.
   a. Automatics and visual notification of all critical alarms.
   b. Read and write access to all data points.
   c. Full length names of data points, schedules, calendars, parameters, alarm texts, state texts and alarms.
   d. Read and write access to all application parameters.
   e. Read and write access to all schedules and calendars.
   f. Read access to the onboard alarm buffer.
   g. Overview of all data points in manual override.
   h. Overview of all data points in alarm.
5. Local Operator Interface shall allow user access to text information via a push & turn operation wheel.
   a. Scrolling through a list of information shall be accomplished by turning the operation wheel.
   b. Selecting and acknowledging information shall be accomplished by pushing the operation wheel.

6. Changing information shall be accomplished by turning the operation wheel.

2.12 UNITARY IP CONTROL UNIT (UICU) – Brand Name: CIPer Model 10

A. HVAC UICU controllers shall be fully programmable to meet the unique requirements of the HVAC equipment it shall control. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework®, that allow standard and customizable control solutions required in executing the "Sequence of Operation". Each UICU shall include the Niagara Security Dashboard.

B. All UICUs shall be application programmable and shall always maintain their certification. All control sequences within or programmed into the UICU shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.

C. The controllers shall be capable of daisy-chain IP communications with other UICU's and peer-to-peer communications with SNC's and with any OWS connected to the BAS, whether the OWS is directly connected, connected via cellular modem, or connected via the Internet.

D. The communication protocols utilized for peer-to-peer communications between UICU's will be Niagara 4 FoxS or BACnet® TCP/IP. Use of a proprietary communication protocol for peer-to-peer communications between UICU's is not allowed.

E. The UICU shall be licensed and enabled to support two (2) devices and shall be licensed with the following Open protocol drivers by default:
1. BACnet® IP and BACnet® MSTP
2. Modbus TCP and Modbus RTU
3. SNMP

F. The UICU shall be provided with Lifetime Software Maintenance license. Labor to implement not included.

G. The UICU shall be capable of executing application control programs to provide:
1. Calendar functions.
2. Scheduling.
3. Trending.
4. Alarm monitoring and routing.
5. Time synchronization.
6. Integration of all daisy-chain UICU's.
7. Network management functions for all daisy-chain UICU's.
8. Analytics for BMS fault detection and diagnostics, including sub-system alarm suppression as described in ASHRAE Guideline 36-2018.
9. 10 Niagara N4 Analytic Points.

H. Programming software shall be embedded into the UICU. The UICU shall not require any external configuration tool or programming tool. All configuration and programming tasks shall be accomplished and accessible from within the embedded Niagara 4 environment.

I. The UICU shall support the following security functions.
1. Module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted.
2. Role-Based Access Control (RBAC) for managing user roles and permissions.
3. Require users to use strong credentials.
4. Data in Motion and Sensitive Data at Rest be encrypted.
5. Encrypted (PKI) Secure IP Stack Communication Security.
6. FIPS 140-2 Level 1 Cryptographic Module Compliant.

J. The minimum controller Environmental ratings.
   1. Operating Temperature Ambient Rating: -4 degrees to 140 degrees F (-20 degrees to 60 degrees C).
   2. Storage Temperature Ambient Rating: -40 degrees to 185 degrees F (-40 degrees to 85 degrees C).
   3. Relative Humidity: 5 % to 95 % non-condensing

K. The controller shall have the additional approval requirements, listings, and approvals:
   1. Meets FCC Part 15, Class B (radiated emissions) requirements.
   2. C-UL
   3. CE
   4. UL916, Open Energy Management Class 2
   5. RoHS2
   6. REACH
   7. WEEE
   8. CAN/CSA-C22.2 No. 205-12
   9. The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (2.40” x 7.04” x 4.53”; 61 mm x 179 mm x 115 mm).

L. The UICU shall provide the following hardware features as a minimum:
   1. The UICU shall provide LED indication of Power, Fault, Ethernet TX/RX/Traffic/Speed without cover removal.
   2. ARM Cortex-A9/M4 9, 800 MHz
   3. 512 MB DDR SDRAM
   4. 2 GB Flash Memory
   5. Powered from 24 VAC/DC source
   6. Two 10/100 MB Ethernet ports capable of daisy chaining
   7. 1 RS-485 Serial Port
   8. Real Time Clock
   9. Secure Boot
   10. Ten [10] onboard IO points
   11. Supports up to 3 devices or 50 Points.

M. The UICU shall support standard Web browser access via the Intranet/Internet.

N. The UICU shall be able to route any alarm condition to any defined user location whether connected to a local network or wide-area network.
   1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:
      a. Alarm.
      b. Return to normal.
      c. To default.
   2. Alarms shall be annunciated in any of the following manners as defined by the user:
      a. Screen message text.
      b. Email of complete alarm message to multiple recipients.
      c. Pagers via paging services that initiate a page on receipt of email message.
      d. Graphics with flashing alarm object(s).
   3. The following shall be recorded by the UICU for each alarm (at a minimum):
      a. Time and date.
      b. Equipment (air handler #, access way, etc.).
      c. Acknowledge time, date, and user who issued acknowledgement.

O. UICU Controllers shall support at minimum the following control techniques:
   1. General-purpose control loops that can incorporate Demand Limit Control strategies, set point reset, adaptive intelligent recovery, and time of day bypass.
   2. General-purpose, non-linear control loops.
   3. Start/stop Loops.

4. If/Then/Else logic loops.
5. Math Function loops (MIN, MAX, AVG, SUM, SUB, SQRT, MUL, DIV, ENTHALPY).
6. Analytic calculations.

P. The following five [5] Universal Inputs shall be supported per each UICU:
1. Type 3 10 K Thermistor
2. 0-100 K ohm
3. 0-10 VDC
4. 0-20 mA with external resistor
5. Dry Contact

Q. The following two [2] Analog Outputs shall be supported per each UICU:
1. 0-10 VDC, 4 mA max output current

R. The following three [3] Digital Outputs shall be supported per each UICU:
1. Triac, 24 VAC @ 0.5 amp

S. The UICU shall employ a 50 Point Base License that supports one [1] IO-R-34 expansion module over a shielded RS-485 bus or three [3] devices via the embedded protocols.

T. Each UICU shall have expansion ability to support additional I/O requirements through the use of a remote input/output module connected to an RS-485 local communication bus. Each UICU shall be able to support a maximum of one [1] 34 Point Expansion I/O Modules for a maximum of 44 physical I/O points.
1. 34 Point Mixed Expansion I/O Module shall communicate with UICU via a 2-wire RS-485m bus.
2. Sixteen [16] Universal Inputs shall be supported via 34 Point Expansion I/O Module:
   a. Type 3 10 K Thermistor
   b. 0-100 K ohm
   c. 0-10 VDC
   d. 0-20 mA with external resistor
3. Eight [8] Analog Outputs shall be supported via 34 Point Expansion I/O Module:
   a. 0-10.0 VDC
4. Ten [10] Digital Outputs (Relay) shall be supported via 34 Point Expansion I/O Module:
   a. Form A Contacts, 24 VAC at 0.5 A rated

U. The UICU shall not include an integrated Local Operator Interface.

2.13 ADVANCED UNITARY CONTROLLER (AUC) – Brand Name: Spyder Classic/Stryker/Spyder Model 5

A. The advanced unitary controller (AUC) platform shall be designed specifically to control HVAC - ventilation, filtration, heating, cooling, humidification, and distribution. Equipment includes constant volume air handlers, VAV air handlers, packaged RTU, heat pumps, unit vents, fan coils, natural convection units and radiant panels. The control shall use **<LonMark or BACnet®>** based devices where the application has a LonMark profile or BTL Listed PICS defined. Where LonMark devices are not available for a particular application, devices based on LonWorks shall be acceptable. For each LonWorks device that does not have LonMark certification, the device supplier shall provide an XIF file for the device. The controller platform shall provide options and advanced system functions, programmable and configurable, using Niagara 4 Framework®, that allow standard and customizable control solutions required in executing the "Sequence of Operation".

B. Minimum Requirements:
1. The controller shall be fully programmable or configurable with full functionality on any Niagara 4 brand platform.

a. Support downloads to the controller in Niagara 4 platform.
b. Support uploads from the controller to Niagara 4 platform.
c. Support simulation/debug mode of the controller.
d. Maintain native GUI.
e. Native function-block programming software and all controller "Setup Wizards" shall be embedded within the Niagara 4 environment.

2. The AUC shall be capable of either integrating with other devices or stand-alone operation.
3. For VAV box applications, the AUC shall have an internal velocity pressure sensor.
   a. Sensor Type: Microbridge air flow sensor with dual integral restrictors.
   b. Operating Range: 0-to-1.5-inch H2O (0 to 374 Pa).
   c. Accuracy: +/- 2 % of full scale at 32 degrees to 122 degrees F (0 degrees to 50 degrees C); +/- 1 % of full scale at null pressure.
4. The AUC shall have two microprocessors. The Host processor contains on-chip FLASH program memory, FLASH information memory, and RAM to run the main HVAC application. The second processor for network communications. Controller memory minimum requirements include:
   a. FLASH Memory Capacity: 60 Kilobytes with 8 Kilobytes for application program.
   b. FLASH Memory settings retained for ten years.
   c. RAM: 2 Kilobytes.
5. The AUC shall have an internal time clock with the ability to automatically revert from a master time clock on failure.
   a. Operating Range: 24-hour, 365-day, multi-year calendar including day of week and configuration for automatic day-light savings time adjustment to occur on configured start and stop dates.
   b. Accuracy: +/- 1 minute per month at 77 degrees F (25 degrees C).
   c. Power Failure Backup: 24 hours at 32 degrees to 122 degrees F (0 degrees to 50 degrees C).
6. The AUC shall have Significant Event Notification, Periodic Update capability, and Failure Detect when network inputs fail to be detected within their configurable time frame.
7. The AUC shall have an internal DC power supply to power external sensors.
   a. Power Output: 20 VDC +/- 10 % at 75 mA.
8. The AUC shall have a visual indication (LED) of the status of the devise:
   a. Controller operating normally.
   b. Controller in process of download.
   c. Controller in manual mode under control of software tool.
   d. Controller lost its configuration.
   e. No power to controller, low voltage, or controller damage.
   f. Processor and/or controller are not operating.
9. The minimum AUC Environmental ratings.
   a. Operating Temperature Ambient Rating: -40 degrees to 150 degrees F (-40 degrees to 65.5 degrees C) for an AUC in unconditioned space.
   b. Storage Temperature Ambient Rating: -40 degrees to 150 degrees F (-40 degrees to 65.5 degrees C) for an AUC in unconditioned space.
   c. Operating Temperature Ambient Rating: 32 degrees to 122 degrees F (0 degrees to 50 degrees C) for an AUC in conditioned space.
   d. Storage Temperature Ambient Rating: 32 degrees to 122 degrees F (0 degrees to 50 degrees C) for an AUC in conditioned space.
   e. Relative Humidity: 5 % to 95 % non-condensing.
10. The AUC shall have the additional approval requirements, listings, and approvals:
    a. UL/cUL (E87741) listed under UL916 (Standard for Open Energy Management Equipment) with plenum rating.
    b. CSA (LR95329-3) Listed.
    c. Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.

d. Meets Canadian standard C108.8 (radiated emissions).
e. Conforms requirements European Consortium standard EN 61000-6-1; 2001 (EU Immunity).
f. Conforms requirements European Consortium standard EN 61000-6-3; 2001 (EU Emission).

11. The AUC housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5 mm x 35 mm).
12. For VAV box applications, the AUC shall provide an integrated actuator option.
    a. Actuator type: Series Floating.
    b. Rotation stroke: 95 degrees +/- 177; 3 degrees for CW or CCW opening dampers.
    c. Torque rating: 44 lb-inch (5 Nm).
    d. Run time for 90-degree rotation: 90 seconds at 60 Hz.
13. The AUC shall have a mix of Universal Inputs (UI), Digital Inputs (DI), Analog Outputs (AO), and Digital Triac Outputs (DO), as well as a 2-wire, polarity insensitive, AUC communication bus providing Sensor, Actuator, and I/O expandability.
    a. Analog outputs (AO) shall be capable of being configured as digital outputs (DO).
    b. Input and Output wiring terminal strips shall be removable from the controller without disconnecting wiring.
    c. Input and Output wiring terminals shall be designated with color coded labels.
    d. Universal inputs shall be capable of being configured as binary inputs, resistive inputs, voltage inputs (0-10 VDC), or current inputs (4-20 mA).
14. The AUC shall provide "continuous" automated loop tuning with an Adaptive Integral Algorithm Control Loop.
15. The AUC platform shall have standard HVAC application programs that are modifiable to support both the traditional and specialized "sequence of operations" as outlined in Section 4.
    a. Discharge air control and low limit.
    b. Pressure-dependent dual duct without flow mixing.
    c. Variable air volume with return flow tracking.
    d. Economizer with differential enthalpy.
    e. Minimum airflow coordinated with CO2.
    f. Unit ventilator cycle (1, 2, 3) 2-pipe.
    g. Unit ventilator cycle (1, 2, 3) 2-pipe with face/bypass.
    h. Unit ventilator cycle (1, 2, 3) 4-pipe.
    i. Unit ventilator cycle (1, 2, 3) 4-pipe with EOC valve.
    j. VAV terminal unit.
    k. VAV terminal unit fan speed control.
    l. Series fan.
    m. Parallel fan.
    n. Regulated air volume (room pressurization/de-pressurization).
    o. CV dual duct.
    p. Room CO2 control.
    q. Room Humidity.
    r. TOD occupancy sensor stand-by set points.

2.14 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, and Honeywell Sylk™.
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 (≥ 100K ohms), or closed circuit (≤100ohms).
   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 (≥ 100K ohms), or closed circuit (≤100ohms).
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.

2.15 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 (2-wire Sylk™ 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 Honeywell Sylk™.
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 (≥ 100K ohms), or closed circuit (≤100ohms).
   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 (≥ 100K ohms), or closed circuit (≤100ohms).
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.

2.16 PLC - PROGRAMMABLE LOGIC CONTROLLER

See Division 40 63 43 PROGRAMMABLE LOGIC CONTROLLER document ***40 63 43 Honeywell SBC PLC BMS (2025-11-24)***

2.17 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 ½, ¾ 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 ½” 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 or Temperature, Humidity, and CO2.
   3. Vertical or Horizontal orientation.
   4. Ability to display multiple parameters:
      a. Space Temperature.
      b. Space Humidity.
      c. Space CO2.
      d. Space Setpoint.
      e. Outdoor Temperature.
      f. Outdoor Humidity.
      g. Current Time.
      h. Or any one other parameter in the controller.
   5. Honeywell is the basis of design.

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, CO2, PM1.0, PM2.5, PM10, and TVOC. Output via BACnet® MS/TP or Modbus RTU or Sylk™. Sensors shall be wall mounted type with Air Quality Score, individual

parameter description/ units incorporated into display. Air Quality score shall be based on CO2, PM2.5, 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 $\mu g/m^3$, accuracy ±10 $\mu g/m^3$, 0-100 $\mu g/m^3$, 101-500 $\mu g/m^3$, ±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”.

2.18 GRAPHICAL PROGRAMMING

A. The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in all control modules. Any system that does not use a drag and drop method of graphical icon programming shall not be accepted. All systems shall use a GPL method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.

B. Graphic programming shall be performed while on screen and using a mouse; each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.

C. Graphic Sequence: The clarity of the graphic sequence shall be such that the operator has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming shall be self-documenting and provide the operator with an understandable and exact representation of each sequence of operation.

D. GPL Capabilities: The following is a minimum definition of the capabilities of the Graphic

Programming software:

1. Function Block (FB): Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.
2. Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.
3. Microblocks: Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors bid.
4. Wires: Shall be Graphical elements used to form logical connections between microblocks and between logical I/O.
5. Reference Labels: Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e., two points labeled 'A' on a drawing are logically connected even though there is no wire between them.
6. Parameter: A parameter shall be a value that may be tied to the input of a microblock.
7. Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields and shall contain 'push buttons' for the purpose of selecting default parameter settings.
8. Icon: An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes its function.
9. Menu-bar Icon: Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.
10. Live Graphical Programs: The Graphic Programming software shall support a ' live' mode, where all input/output data, calculated data and set points shall be displayed in a ' live' real-time mode.

2.19 LONWORKS NETWORK MANAGEMENT

A. Systems requiring the use of third-party LonWorks network management tools shall not be accepted.

B. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.

C. The Network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices and to view health and status counters within devices.

D. These tools shall provide the ability to "learn" an existing LonWorks network, regardless of what network management tool(s) were used to install the existing network, so that existing LonWorks devices and newly added devices are part of a single network management database.

E. The network management database shall be resident in the Network Area Controller (NAC), ensuring that anyone with proper authorization has access to the network management database at all times. Systems employing network management databases that are not resident, at all times and within the control system shall not be accepted.

PART 3 EXECUTION

3.1 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.

B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.2 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.3 GENERAL

A. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.

B. Line and low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by the Control System Contractor in accordance with these specifications.

C. Equipment furnished by the Mechanical Contractor that is normally wired before installation shall be furnished completely wired. Control wiring normally performed in the field will be furnished and installed by the Control System Contractor.

D. All control devices mounted on the face of control panels shall be clearly identified as to function and system served with permanently engraved phenolic labels.

3.4 WIRING

A. All electrical control wiring to the control panels shall be the responsibility of the Control System Contractor.

B. All wiring shall be in accordance with the Project Electrical Specifications (Division 16), the National Electrical Code and any applicable local codes. All control wiring shall be installed in raceways.

C. Excess wire shall not be looped or coiled in the controller cabinet.

D. Incorporate electrical noise suppression techniques in relay control circuits.

E. There shall be no drilling on the controller cabinet after the controls are mounted inside.

F. Careful stripping of wire while inside the cabinet is required to ensure that no wire strand fragments land on circuit boards.

G. Use manufacturer-specified wire for all network connections.

H. Use approved optical isolation and lightning protection when penetrating building envelope.

I. Read installation instructions carefully. Any unavoidable deviations shall be approved by the owner's rep prior to installation.

3.5 ACCEPTANCE TESTING

A. Upon completion of the installation, the Control System Contractor shall load all system software and start-up the system. The Control System Contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to ensure that the system is functioning in full accordance with these specifications.

B. The Control System Contractor shall perform tests to verify proper performance of

components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100 % of the input and output points of the DDC system operation.

C. System Acceptance: Satisfactory completion is when the Control System Contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

3.6 OPERATOR TRAINING

A. During system commissioning and at such time acceptable performance of the Control System hardware and software has been established, the Control System Contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction shall be done during normal working hours and shall be performed by a competent representative familiar with the system hardware, software, and accessories.

B. The Control System Contractor shall provide 48 total hours of comprehensive training in multiple sessions for system orientation, product maintenance and troubleshooting, programming, and engineering. These classes are to be spread out during the 1st year warranty period. The first class starts after final commissioning and the last class is to be in the last month of a 1-year warranty period.

3.7 WARRANTY PERIOD SERVICES

A. Equipment, materials, and workmanship incorporated into the work shall be warranted for a period of one year from the time of system acceptance.

B. Within this period, upon notice by the Owner, any defects in the BMS due to faulty materials, methods of installation or workmanship shall be promptly repaired or replaced by the Control System Contractor at no expense to the Owner.

C. Maintenance of Computer Software Programs: The Control System Contractor shall maintain all software during the standard first year warranty period. In addition, all factory or sub-vendor upgrades to software during the first-year warranty period shall be added to the systems, when they become available, at no additional cost. In addition to first year standard warranty, software provided by Control System Contractor shall come with a 5 Year Software Maintenance license. All SNC and BAS Servers are included in this coverage. Labor to implement upgrades in years two through five are not included in the standard warranty.

D. Maintenance of Control Hardware: The Control System Contractor shall inspect, repair, replace, adjust, and calibrate, as required, the controllers, control devices and associated peripheral units during the warranty period. The Control System Contractor shall then furnish a report describing the status of the equipment, problem areas (if any) noticed during service work, and description of the corrective actions taken. The report shall clearly certify that all hardware is functioning correctly.

E. Service Period: Calls for service by the Owner shall be honored within 24 hours and are not to be considered as part of routine maintenance.

F. Service Documentation: A copy of the service report associated with each owner-initiated service call shall be provided to the owner.

3.8 WARRANTY ACCESS

A. The Owner shall grant to the Control System Contractor reasonable access to the BMS

during the warranty period. Remote access to the BMS (for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period) will be allowed.

3.9 OPERATION & MAINTENANCE MANUALS

A. See Division 1 for requirements. O&M manuals shall include the following elements, as a minimum:
   1. As-built control drawings for all equipment.
   2. As-built Network Communications Diagram.
   3. General description and specifications for all components.
   4. Completed Performance Verification sheets.
   5. Completed Controller Checkout/Calibration Sheets.

3.10 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION