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AUTHORITY

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Addendum No.2
Request for Bids
Greater Columbus Convention Center South Facility
Air Handler Replacement

Information contained within this Addendum No.2 modifies the December 19, 2022, Project Manual for the Greater Columbus Convention Center South Facility Air Handler Replacement. Receipt of this Addendum must be indicated on the Form of Proposal submitted by each bidder.

Submittal Deadline Change

The FCCFA has determined that it is in the best interest of the organization to extend the bid date. Bids will now be due on or before **January 25, 2023, at 4:00 PM EST.** Bids should be delivered to the FCCFA offices as indicated in the Project Manual. Bids will be opened and read aloud immediately following the submittal deadline.

Specification Changes

1. 23 73 00 MODULAR AIR HANDLING UNITS – Added Daikin, JCI, and Temtrol as approved manufacturers for modular air handing units.

2. 23 09 23 BUILDING AUTOMATION SYSTEM FOR HVAC – Added Comfort Systems USA as approved BAS control system.

Request for Information

The FCCFA received the following questions prior to the January 9, 2023, deadline for the submittal of questions:

1. **Will temporary heating be required?**

   The necessity of temporary heating is dependent upon the construction schedule.

2. **Does the FCCFA have a preferred fire sprinkler contractor?**

   No, there is no preferred fire sprinkler contractor.

3. **What is the anticipated work schedule? Will nights and weekends be required?**

   The FCCFA anticipates that all work will be completed during normal business hours. Depending upon the facility's event schedule there may be times were work stoppages are required. Overnight and weekend work will be permitted but it is not anticipated to be required.

4. **Will air balancing be required for each unit?**

   Each new air handling unit should provide at least the same CFM as the current units.

5. **Will additional site visits be scheduled?**

   Additional site visits may be scheduled by contacting Randy Chrisman, FCCFA Capital Projects Manager, at 614-827-2803. The FCCFA will provide access to the existing mechanical spaces but will not answer additional questions at these visits.

6. **Can York and Temtrol be included as approved manufacturers?**

   Yes, please see the attached updated specifications.

7. **Is Daikin an acceptable alternative manufacturer?**

   Yes, please see the attached updated specifications.

8. **Can Comfort Systems USA be included as an approved contractor for building automation and controls?**

   Yes, please see the attached updated specifications.

9. **Should costs to drain the existing energy recovery coil and disposal of glycol be included in the base bid?**

   Bids for demolition of the existing energy recovery system for each existing air handling system AC-H-1, AC-H-2, AC-H-3, AC-H-4, should include disposal of any fluid in the existing system.

10. **Please confirm the interior dimensions of the freight elevator.**

    Freight elevator dimensions will be verified and provided in Addendum 3.

11. **Should costs related to protection of existing finishes be included in the base bid? Which areas will require protection?**

    Every permanent item in the work area that is not shown to be demolished needs to be protected from damage. Damaged items will be replaced and repaired by the selected contractor at no expense to the Owner. Items that are currently being stored in the area will be relocated by the Owner. If there are specific items that could be moved to facilitate ease of installation, then it will be addressed individually at a later date.

12. **Who is the current/preferred water treatment vendor for the Greater Columbus Convention Center? Can a water treatment specification be provided?**

    Kurita is the current water treatment vendor. Treatment specifications will be provided in Addendum 3.

13. **Will contractors be responsible for their own parking costs?**

    Yes, contractors will be responsible for parking costs. Parking is available at the Greater Columbus Convention Center's Ohio Center Garage, East Surface Lot, or South Garage.

14. **Will a single prime contract be used for the mechanical contractor?**

    Yes. The FCCFA will utilize the A104-2017 Standard Abbreviated Form of Agreement Between Owner and Contractor for this project. A draft agreement was included in the bid documents.

15. **Will the new units sit on the existing pads?**

    Yes, the existing pads will remain in place, however, the existing pad does not provide full support for the new units and may require expansion. The final pad must provide full concrete support under the installed units.

16. **Who is the manufacturer for the two existing motor control centers listed on drawing E002?**

    General Electric.

Please note the amended due date of January 25, 2023, at 4:00 PM EST.

Sincerely,

Jordan Edmonds
In-House Counsel, FCCFA

23 09 23 BUILDING AUTOMATION SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 Overview

A. All control work furnished under this contract shall be an extension of, and fully integrated with, the existing Trane Controls System or Comfort Systems USA in the Building. The intent is not to replace the DDC control system, but to expand as necessary to accommodate and control the new HVAC systems and equipment with the existing controls system.

B. Furnish all labor, materials and equipment necessary for a complete and operating Building Automation System (BAS), utilizing direct digital controls and electric actuation as shown on the drawings and as described herein. Drawings are diagrammatic only.

C. System software shall be based on a server/thin-client architecture, designed around the open standards of web technology. The control system server shall be accessed over the control system network, the Owner's local area network, and remotely over the Internet (through the Owner's LAN).

D. Performance Monitoring: The BAS will provide the specified performance monitoring functionality, including required monitoring points and performance metrics, improved through system accuracy, data acquisition and data management capabilities, and required graphical and data displays.

E. The intent and requirement of this specification and related sections is to provide a fully integrated, open, interoperable, peer-to-peer, networked, and distributed BAS. The following communication protocols are acceptable:

1. ANSI/ASHRAE Standard 135 BACnet - A Data Communication Protocol for Building Automation and Control Networks
2. Tridium Niagara Framework Protocol

F. The BAS shall be comprised of:

1. Communications Network
2. Enterprise Network Server
3. Embedded Controller/Web Server(s)
4. Graphical User Interface
5. Equipment controllers (B-AAC, B-ASC, MEC)
6. Sensors (refer to Section 23 09 25)
7. Controlled devices (refer to Section 23 09 25)

G. Software License Agreement

1. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract, and shall give him and their authorized agent full access to all features and functions of the installed BAS. Such license shall grant use of all programs and application software to Owner and their authorized agent as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.
2. It is the Owner's express goal to implement an open system that will allow products from various suppliers to be integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the system. The Owner shall be the named license holder of all software associated with any and all incremental work on the project. In addition, the Owner shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all

configuration and programming that is generated for a given project and/or configured for use with the Enterprise Network Server, Embedded Controller/Web Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required IDs and passwords for access to any component or software program shall be provided to the owner. The owner shall determine which organizations to be named in the SI organization ID ("orgid") of all software licenses. All NiagaraAX or Niagara 4 software licences shall have the following NiCS: "accept.station.in=*"; "accept.station.out=*"; "accept.wb.in=*"; "accept.wb.out=*". All open NIC statements shall follow Niagara Open NIC specifications. Owner shall be free to direct the modification of the "orgid" in any software license, regardless of supplier, by Tridium Inc.

H. All Embedded Controller/Web Servers shall be accessed via a single connection to the Enterprise Network Server. In this configuration, each Embedded Controller/Web Server can be accessed from a PC using Remote Desktop Connection Client User Interface and from a PC using Web Browser Client User Interface.

I. Local connections shall be via an Ethernet LAN. Remote connections shall be via Owner provided full-time, high-speed ISP connection for remote site access (i.e., T1, ADSL, cable modem) and IPv6 compliant. The owner shall be responsible for all monthly internet access fees and connection charges.

J. The basic control system includes all sensors, controllers, instruments, valves, actuators, devices, installation and service for a complete and functional control system. All control devices (valves, dampers, actuators, etc.) and associated power and control wiring shall be included. Refer to Section 23 09 25 Instrumentation and Control Devices for HVAC and Section 23 09 47 Control Power and Wiring for HVAC. The BAS shall be designed to allow easy field adjustment of all set points and parameters.

K. Provide for future system expansion to include monitoring of the access, intrusion detection, fire alarm, and lighting control systems.

L. Identify active or inactive pneumatic tubing, control wiring, equipment, etc., and where requested assist in the actual removal. Remove all pneumatic tubing, control wiring, and control devices not required to accommodate the new control system.

1.2 Provider Requirements

A. Manufacturer Qualifications

1. All products used in the installation shall be new, currently under manufacture, and shall be applied in standard off the shelf products. The installation shall not be used as a test site for any new products unless explicitly approved by the Engineer in writing. Spare parts shall be made available for at least 10 years after completion of this contract.

B. Installer Qualifications

1. Installing Contractor shall have an established working relationship with Control System Manufacturer of not less than 5 years.
2. Installing Contractor and their Sub-Contractors shall have successfully completed manufacturer's control system training. Provide certification of completed training, including hours of instruction and course outlines, within 10 days after bid date.
3. Installing Contractor shall have an office within 75 miles of the project site and provide 24 hour response in the event of a customer call, 7-days per week, 365 days per year.

C. Any Manufacturer or Installing Contractor not pre-qualified above shall submit credentials for the Engineer's review seven or more days prior to the bid date. Applications submitted after seven days prior to the bid date will not be considered. Credentials must attest that the

manufacturer and installer meet all requirements above. The Engineer's judgment in reviewing any manufacturer or contractor will be final.

1.3 Technical Proposal

A. Provide a technical proposal to the Engineer after bidding and before award of a contract when so requested by the Engineer. The Engineer's review comments will be made available to the bidder two weeks after receipt of the technical proposal. The technical proposal shall contain the following:

1. Description of how the system meets and achieves the specified criteria in terms of configuration, operation and control.
2. BAS single line riser diagram, showing all major components (digital controllers, bus network, etc.).
3. Procedure and amount of time required to start up the system.
4. Bidder shall explain:
   a. How Owner programs (language, etc.) the system.
   b. Any proprietary software for which documentation is not available.
   c. Manufacturer of major components.
   d. Requirements of the off-site data terminal to access to BAS over telephone communications.

B. For all application programs supplied, bidder shall explain in the technical proposal, program constraints and limitations, and listing of all systems the program is applied to, including digital controller interface and control of:
1. Typical air handling unit and roof top unit.
2. Hot water control.

C. An interview may be conducted and each bidder will be requested to make a presentation concerning the system proposed.

1.4 Codes and Standards

A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions of the following codes and standards:

1. National Electric Code (NEC)
2. Ohio Building Code (OBC) and Ohio Mechanical Code (OMC)
3. National Fire Protection Association (NFPA)
4. ANSI/ASHRAE Standard 55 Thermal Environmental Conditions For Human Occupancy
5. ANSI/ASHRAE Standard 62 Ventilation For Acceptable Indoor Air Quality
6. ANSI/ASHRAE Standard 90.1 Energy Standard For Buildings Except Low-Rise Residential Buildings
7. ANSI/ASHRAE Standard 135, BACnet - A Data Communication Protocol for Building Automation and Control Networks
8. Underwriters Laboratories: Products shall be UL-916-PAZX Listed

1.5 The following sections constitute related work:

A. Section 23 09 25 – Instrumentation and Control Devices for HVAC

B. Section 23 09 47 – Control Power Wiring for HVAC

C. Section 23 09 93 – Sequence of Operation for HVAC Controls.

1.6 System Performance

A. Performance Standards. System shall conform to the following minimum standards over network connections:

1. Graphic Display. A graphic with 20 dynamic points/objects shall display with current data within 10 seconds.
2. Graphic Refresh. A graphic with 20 dynamic points/objects shall update with current data within 8 seconds.
3. Object Command. Devices shall react to command of a binary object within 2 seconds. Devices shall begin reacting to command of an analog object within 2 seconds.
4. Object Scan. Data used or displayed at a controller or user interface shall have been current within the previous 6 seconds.
5. Alarm Response Time. An object that goes into alarm shall be annunciated at the user interface within 45 seconds
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 second. Select execution times consistent with the mechanical process under control.
7. Performance. Programmable controllers shall be able to completely execute BAS PID control loops at a frequency adjustable down to once per second. Select execution times consistent with the mechanical process under control.
8. Multiple Alarm Annunciations. Each user interface on the network shall receive alarms within 5 seconds of other user interfaces.
9. Reporting Accuracy. System shall report values with the minimum end-to-end accuracy listed in Table 1 of Section 23 09 25 Instrumentation and Control Devices.
10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2 of Section 23 09 25 Instrumentation and Control Devices.

1.7 Submittals

A. Refer to Section 23 05 01 – Basic HVAC Requirements and Division 1.

B. Begin no work until submittals have been approved for conformity with design intent. Provide drawings as AutoCAD 2009 (or newer) compatible files on optical disk (file format: .dwg, .dxf, .vsd, or compatible) with 11 inches x 17 inches prints of each drawing. When manufacturer's cutsheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Damper and valve schedules and data sheets may be submitted separately to improve product delivery dates. Provide submittals within 12 weeks after contract award, including the following:

1. BAS Hardware
   a. Complete bill of materials indicating quantity, manufacturer, model number, and other relevant technical data.
   b. Manufacturer's description and technical data, such as performance curves, product specification sheets, and installation and maintenance instructions for items listed below and for other relevant items not listed below:
      1) DDC (controller) panels
      2) Transducers and transmitters
      3) Sensors (including accuracy data)
      4) Actuators
      5) Valves
      6) Dampers
      7) Relays and switches
      8) Control panels
      9) Power supplies

10) Batteries
11) User interface equipment
12) Wiring

c. Wiring diagrams and layouts for each control panel. Show all termination numbers.
d. Floor plan schematic diagrams indicating field sensor, controller and power supply locations.

2. Network and User interface Hardware and Software
   a. Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.
   b. Manufacturer's description and technical data, such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:
      1) Central Processing Unit (CPU)
      2) Monitors
      3) Keyboards
      4) Power supply
      5) Battery backup
      6) Interface equipment between CPU and control panels
      7) Routers
      8) Repeaters
      9) Operating System software
      10) User interface software
      11) Color graphic software
      12) Third-party software
   c. Schematic diagrams of control, communication, and power wiring for central system installation. Label cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to control system.
   d. List of color graphics to be provided. Provide a conceptual layout of pictures and data for each graphic, showing or explaining which other graphics can be directly accessed.
3. Controlled Systems
   a. Riser diagrams showing control network layout, communication protocol, and wire types.
   b. Schematic diagram of each controlled system. Label control points/objects with point/object names. Graphically show all locations of control elements.
   c. Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.
   d. Instrumentation list for each controlled system. List each control system element in a table format. Show element name, type of device, manufacturer, model number, and product data sheet number.
   e. Mounting, wiring, and routing plan view drawing in 0.25 inch scale. Take into account HVAC, electrical and other systems' design and elevation requirements. Show locations of concrete pads and bases and special wall bracing for panels to accommodate this work.
   f. Complete description of control system operation including sequences of operation. Include and reference a schematic diagram of system.
   g. Point/object list for each system controller including inputs and outputs (I/O), point/object numbers, controlled device associated with each I/O point/object, and location of I/O device. Indicate alarmed and trended points/objects.
4. Description of process, report formats, and checklists to be used in Part 3: "Control System Demonstration and Acceptance."
5. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of BACnet controller (B-BC, B-AAC, B-AVAVC, B-ASC) and user interface (B-OWS).
6. Instrumentation and Data Point Summary Table. Contractor shall submit in table format with the following information for each instrument and data point. The table is to be reviewed and approved by the owner's representative prior to hardware and software installation and programming.

a. Point name
b. Point description: provide building designation, system type, equipment type, engineering units, and functionality; include a description of its physical location
c. Expected range (upper and lower limit)
d. Instrumentation (as applicable): manufacturer, model number, range, and accuracy specification
e. Type
    1) AI: analog input
    2) BI: binary input
    3) NAI: network analog input
    4) NBI: network binary input
    5) P: programmed (e.g., soft or virtual point in control sequence such as a PID input or output)
    6) C: calculated value; a soft or virtual point. If calculated value, provide logic diagrams or code and any constants used in formula. If time-based integrated values are required, provide time periods: minutes, daily, weekly, monthly, and yearly. Also indicate if it is a running average.
f. Input resolution
g. Graphic display resolution
h. Data trend interval
i. Number of samples stored in local controller before transfer to host computer/server database
j. Data point address

C. Schedules

1. Provide a Schedule of work within one month of contract award indicating:
    a. Intended sequence of work items
    b. Start date of each work item
    c. Duration of each work item
    d. Planned delivery dates for ordered material and equipment, and expected lead time
    e. Milestones indicating possible restraints on work by other trades or situations
2. Monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated schedule of work.

D. Project Record Documents. Submit three copies of record (as-built) documents upon completion of installation for approval prior to final completion. Submittal shall consist of:

1. Project Record Drawings.
    a. As-built versions of the submittal shop drawings provided as AutoCAD 2009 (or newer) compatible files on optical media and as 11 inches x 17 inches prints.
    b. Submittals to include complete electrical point-to-point wiring diagrams, component layouts, system and equipment component sequences of operation, start-up and checkout procedures. Include a list of all unit default safety and control settings, whether fixed or adjustable, as shipped from the factory. Where field modifications are required to meet the specification, provide all modification labor and materials, and submit a complete, detailed, step-by-step procedure for the modifications.
2. Testing and Commissioning Reports and Checklists. Completed versions checklists and trend logs used to meet requirements of Part 3: “Control System Demonstration and Acceptance.”
3. Operation and Maintenance (O & M) Manual.
    a. As-built versions of the submittal product data.
    b. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
    c. User’s manual with procedures for operating control systems: logging on and off, handling alarms, producing point/object reports, trending data, overriding computer control, and changing setpoints and variables.

d. Programming manual or set of manuals with description of the programming language and syntax of statements for algorithms and calculations used of point/object database creation and modification, of program creation and modification, and editor use.
e. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points/objects, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
f. Documentation of all programs created using custom programming language including setpoints, tuning parameters, and object database.
g. Graphic files, programs and database on magnetic or optical media.
h. List of recommended spare parts with part numbers and suppliers.
i. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware, including computer equipment and sensors.
j. Complete original-issue copies of furnished software, including operating systems, custom programming language, user interface software, and graphics software.
k. Licenses, guarantee, and warranty documents for equipment and systems.
l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

4. Training Materials: Provide course outline and manuals for each class at least six weeks before the first class. Engineer will modify course outlines and manuals if necessary to meet Owner's needs. Engineer will review and approve course outlines and manuals at least three weeks before first class.

1.8 Warranty

A. Warrant all work as follows:
1. Warrant labor and materials for specified BAS free from defects for a period of 12 months after final acceptance. BAS failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. Respond during Owner's business hours within 24 hours of Owner's warranty service request.
2. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
3. If Engineer determines that equipment and systems operate satisfactorily at the end of the final start-up, testing, and commissioning phase, Engineer will certify in writing that BAS operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
4. Provide updates to user user interface software, project-specific software, graphic software, database software, and firmware which resolve Contractor identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above mentioned items. Do not install updates or upgrades without Owner's written authorization.
5. Exception: Reused devices shall not be required to be warranted except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer's acceptance.

1.9 Ownership of Proprietary Material

A. Project specific software and documentation shall become Owner's property. This includes, but is not limited to:

1. Graphics
2. Record drawings
3. Database
4. Application programming code

5. Documentation

PART 2 - PRODUCTS

2.1 Materials

A. The equipment specified shall be provided as defined herein, shown on the drawings and as required to accomplish the sequences of control.

B. Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 25 installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner or Owner's Representative. Spare parts shall be available for at least five-years after completion of this contract.

2.2 BACnet Communications

A. Control products, communication media, connectors, repeaters, hubs and routers shall comprise a BACnet BAS. Controllers and user interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.

B. Each controller shall have a communication port for connections to an user interface.

C. Project drawings indicating remote buildings or sites to be connected to the Enterprise network shall allow for communication with each controller on the network as specified in Paragraph D.

D. Network user interface and value passing shall be transparent to network architecture.

1. A user interface connected to the BAS shall allow the user to interface with networked controllers as if directly connected. BAS information such as data, status, reports, system software, and custom programs, shall be viewable and editable from the user interface.
2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be available on the network. Program and test all cross-controller links required to execute specified BAS operation. An authorized user shall be able to manage, maintain, and access the BAS network of controllers.

E. Workstations, Building Control Panels and Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clock daily from an user designated device via the network. The system shall automatically adjust for daylight saving and standard time as applicable.

F. System shall be expandable to at least twice the required data points with additional controllers, associated devices, and wiring. Expansion shall not require user interface hardware additions or software revisions.

2.3 Enterprise Network Server

G. The Enterprise Network Server shall support all Embedded Controller/Web Servers connected to the owner's network whether local or remote.

H. The Enterprise Network Server Software shall provide the following functions, at a minimum:

1. Global Data Access: The Enterprise Network Server shall provide complete access to distributed data defined anywhere in the system.
2. Distributed Control: The Enterprise Network Server shall provide the ability to execute global control strategies based on control and data objects in any Embedded Controller/Web Server in the network, local or remote.

3. The Enterprise Network Server shall include a master clock service for its subsystems and provide time synchronization for all Embedded Controller/Web Servers.
4. The Enterprise Network Server shall accept time synchronization messages from trusted precision Atomic Clock Internet sites and update its master clock based on this data.
5. The Enterprise Network Server shall provide scheduling for all Embedded Controller/Web Servers and their underlying field control devices.
6. The Enterprise Network Server shall provide demand limiting that operates across all Embedded Controller/Web Servers. The Enterprise Network Server must be capable of multiple demand programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.
7. The Enterprise Network Server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to Embedded Controller/Web Servers. Systems not employing this prioritization shall not be accepted.
8. Each Embedded Controller/Web Server supported by the Enterprise Network Server shall have the ability to archive its log data, alarm data and database to the Enterprise Network Server, automatically. Archiving options shall be user-defined including archive time and archive frequency. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. The server software shall utilize a Java Database Connectivity (JDBC) compatible database such as: MS SQL 8.0, Oracle 8i or IBM DB2 and HTTP/HTML/XML, CSV or text formats. BAS systems written to Non -Standard and/or Proprietary databases are NOT acceptable.
9. The Enterprise Network Server shall provide central alarm management for all Embedded Controller/Web Servers supported by the Enterprise Network Server. Alarm management shall include:
    a. Routing of alarms to display, email, and pagers
    b. View and acknowledge alarms
    c. Query alarm logs based on user-defined parameters
10. The Enterprise Network Server shall provide central management of log data for all Embedded Controller/Web Servers supported by the Enterprise Network Server. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:
    a. Viewing and printing log data
    b. Exporting log data to other software applications
    c. Query log data based on user-defined parameters

I. The Enterprise Network Server hardware platform shall have the following minimum requirements:

1. Processor: Intel Xeon x64 (or better), compatible with dual- and quad-core processors
2. Operating System: Windows 10, 64-bit Windows 8.1 Enterprise, Windows Server 2012 R2 Standard, RHEL-7
3. Memory: 8 GB
4. Hard Drive: 1 TB
5. Display: Video card capable of displaying 1024 x 768 pixel resolution or greater
6. Network Support: NIC card rated for at least 1 Gigabit or 10 Gigabit Ethernet

2.4 Embedded Controller/Web Server (EC/WS)

J. Embedded Controller/Web Server(s) shall manage communications between the BACnet Advanced Application Controllers (B-AAC), BACnet Advanced VAV Controller (B-AVAVC), BACnet Application Specific Controllers (B-ASC), and Mechanical Equipment Controllers (MEC) which are connected to its communications trunks, manage communications between itself and other Embedded Controller/Web Servers and with Enterprise Network Server that are part of the BAS, and perform control and operating strategies for the system based on

information from any controller connected to the BAS. All hardware licenses and certificates shall be stored on local MicroSD memory card employing encrypted “safe boot” technology.

K. The communication protocols utilized for peer-to-peer communications between Embedded Controller/Web Servers and with Enterprise Network Server will be Niagara 4 Fox, BACnet TCP/IP and SNMP. Use of a proprietary communication protocol for peer-to-peer communications between Embedded Controller/Web Servers is not allowed.

L. The EC/WS shall employ a device count capacity license model that supports expansion capabilities.

M. The EC/WS shall be enabled to support and shall be licensed with the following Open protocol drivers (client and server) by default:

1. BACnet
2. Lon
3. MODBUS
4. SNMP
5. KNX

N. The EC/WS 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 EC/WS, B-AAC, B-AVAVC, and B-ASC devices.

O. The EC/WS shall provide the following hardware features as a minimum:

1. Two 10/100 Mbps Ethernet ports
2. Two Isolated EIA-485 ports with biasing switches
3. 1 GB RAM
4. 4 GB Flash Total Storage / 2 GB User Storage
5. Wi-Fi (Client or WAP)
6. USB Flash Drive
7. High-Speed Field Bus Expansion
8. -20 to 60 degree C Ambient Operating Temperature
9. Integrated 24 VAC/DC Global Power Supply
10. MicroSD Memory Card employing Encrypted Safe Boot Technology

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

Q. The EC/WS shall provide alarm recognition, storage, routing, management and analysis to supplement distributed capabilities of equipment or application specific controllers.

R. The EC/WS 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

S. Programming software and all controller "Setup Wizards" shall be embedded into the EC/WS.

T. The EC/WS 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

U. The EC/WS 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

V. The EC/WS 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 (B-AAC, B-AVAVC, B-ASC, VFD…) shall have an associated template file for reuse on future project additions.

W. The EC/WS shall be provided with a 5 Year Software Maintenance license. Labor to implement not included.

2.5 Graphical User Interface

X. All Embedded Controller/Web Servers shall be accessed via a single connection to the Enterprise Network Server. In this configuration, each Embedded Controller/Web Server can be accessed from a PC using Thin-Client Remote Desktop Connection User Interface and/or a PC using Thin-Client Web Browser User Interface.

Y. The Thin-Client Remote Desktop Connection User Interface shall use any of the current versions of Windows Server with Remote Desktop Services and shall allow the Enterprise Server to host multiple, simultaneous client sessions. Remote Desktop shall use Remote Desktop Services technology to allow a single session to run remotely. A user shall connect to a Remote Desktop Session Host (RD Session Host) server by using Remote Desktop Connection (RDC) client software. Thin-client hardware devices running an embedded Windows-based operating system shall run the RDC client software to connect to the RD Session Host Enterprise Server.

Z. The Thin-Client Web Browser User Interface shall use any of the current versions of Microsoft Internet Explorer, Microsoft Edge, Mozilla Firefox, or Google Chrome browsers from any computer. The thin-client web browser shall be operating system agnostic, meaning it will support HTML5 enabled browsers without requiring proprietary user interface and

configuration programs or browser plug-ins. Communication between the Thin-Client Web Browser User Interface and the Enterprise Network Server shall offer, at a minimum, encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be Hyper-Text Transfer Protocol (HTTP).

AA. Software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system.

BB. 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.

CC. The user interface shall be completely interactive and shall provide a HTML5 experience that supports the following features as a minimum:

1. Trending.
2. Scheduling.
3. Electrical demand limiting.
4. Duty Cycling.
5. Downloading Memory to field devices.
6. Real time 'live' Graphic Programs.
7. Tree Navigation.
8. Parameter change of properties.
9. Set point adjustments.
10. Alarm / event information.
11. Configuration of users.
12. Execution of global commands.
13. Add, delete, and modify graphics and displayed data.

DD. Software Components: All software shall be the most current version. All software components of the BAS software shall be provided and installed as part of this project. BAS software components shall include:

1. Server Software, Database and Graphical User Interface.
2. 5 Year Software Maintenance Agreement. Labor to implement shall be included.
3. Embedded System Configuration Utilities for future modifications to the system and controllers.
4. Embedded Graphical Programming Tools.
5. Embedded Direct Digital Control software.
6. Embedded Application Software.
7. Embedded Native Function-block programming software and all controller “Setup Wizards”.

EE. Login: On launching the user interface and selecting the appropriate domain name or IP address, the user shall be presented with a login page that will require a login name and strong password. Navigation in the system shall be dependent on the user's role-based application control privileges.

FF. Web Page Navigation: Using a collection of web pages, it shall be constructed to "feel" like a single application, and provide a complete and intuitive mouse/menu driven user interface. It shall be possible to navigate through the system using a web browser to accomplish

requirements of this specification. The GUI shall (as a minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic set point controls, configuration menus for user access, reports and reporting actions for events.

GG. Tree Navigation: Navigation through the GUI shall be accomplished by clicking on the appropriate level of a navigation tree (consisting of an expandable and collapsible tree control like Microsoft's Explorer program) and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the user to select a specific system or equipment and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Geographic, Network, Groups and Configuration.

1. Geographic View shall display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and objects.
2. Groups View shall display Scheduled Groups and custom reports.
3. Configuration View shall display all the configuration categories (Users, Schedule, Event, Reporting and Roles).

HH. Action Pane: The Action Pane shall provide several functional views for each subsystem specified. A functional view shall be accessed by clicking on the corresponding button:

1. Graphics: Using graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic set point controls, web content and other valid HTML elements. The data on each graphic page shall automatically refresh.
2. Dashboards: User customizable data using drag and drop HTML5 elements. Shall include Web Charts, Gauges, and other custom developed widgets for web-browser. User shall have ability to save custom dashboards.
3. Search: User shall have multiple options for searching data based upon Tags. Associated equipment, real time data, Properties, and Trends shall be available in result.
4. Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the user to depress an 'accept/cancel' button.
5. Schedules: Shall be used to create, modify/edit and view schedules based on the systems hierarchy (using the navigation tree).
6. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
7. Charting: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling. User shall have ability to create HTML charts through web browser without utilizing chart builder. User shall be able to drag and drop single or multiple data points, including schedules, and apply status colors for analysis.
8. Logic - Live Graphic Programs: Shall be used to display 'live' graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.
9. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.

II. Color Graphics: The GUI shall make extensive use of color in the graphic pane to communicate information related to set points and comfort. Animated .gifs or .jpg, vector scalable, active set point graphic controls shall be used to enhance usability. Graphics tools used to create graphics shall be non-proprietary and conform to the following basic criteria:

1. Display Size: The GUI user interface software shall graphically display in a minimum of 1024 by 768 pixels 24 bit True Color.
2. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.

3. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective set points. The colors shall be updated dynamically as a zone's actual comfort condition changes.
4. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability. .
5. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
    a. Each piece of equipment monitored or controlled including each terminal unit.
    b. Each building.
    c. Each floor and zone controlled.

JJ. Hierarchical Schedules: Utilizing the Navigation Tree displayed in the GUI, a user (with proper access credentials) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room, or choose to apply a hierarchical schedule to the entire system, site or floor area. For example, Independence Day ' Holiday' for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further user intervention would be required and every control module in the system with would be automatically downloaded with the ' Independence Day' Holiday. All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and graph.

1. Schedules: Schedules shall comply with the BACnet standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:
    a. Types of schedule shall be Normal, Holiday or Override.
    b. A specific date.
    c. A range of dates.
    d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).
    e. Wildcard (example, allow combinations like second Tuesday of every month).
2. Schedule Categories: The system shall allow users to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.
3. Schedule Groups: In addition to hierarchical scheduling, users shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the user shall be able to define an ' individual tenant' group - who may occupy different areas within a building or buildings. Schedules applied to the ' tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the ' tenant group'.
4. Intelligent Scheduling: The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the user schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.
5. Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the user (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).
6. Schedule Summary Graph: The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.

KK. Alarms:

1. Alarm Processing. Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, alarm limit differentials, states, and reactions for each object in the system.
2. Alarm Messages. Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying upon acronyms or other mnemonics.
3. Alarm Reactions. The operator shall be able to determine (by object) what, if any, actions are to be taken during an alarm. Actions shall include logging, printing, starting programs, displaying messages, dialing out to remote stations, paging, providing audible annunciation, or displaying specific system graphics. Each of these actions shall be configurable by workstation and time of day.
4. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.
5. Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an ' Alarms' view. Alarms, and reporting actions shall have the following capabilities:
    a. Alarms View: Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report and a bold URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the system location, address and other pertinent information. An user shall easily be able to sort events, edit event templates and categories, acknowledge or force a return to normal in the Events View as specified in this section.
    b. Alarm Categories: The user shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the user to easily sort through multiple events displayed.
    c. Alarm Templates: Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out of range information.
    d. Alarm Areas: Alarm Areas enable an user to assign specific Alarm Categories to specific Alarm Reporting Actions. For example, it shall be possible for an user to assign all HVAC Maintenance Alarm on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane.
    e. Alarm Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.
    f. Alarm Configuration: Users shall be able to define the type of Alarm generated per object. A ' network' view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.
    g. Alarm Summary Counter: The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement and total number of Alarms in the BAS Server database.
    h. Alarm Auto-Deletion: Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an user defined period.
    i. Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Users shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:
        1) Print: Alarm information shall be printed to the BAS server's PC or a networked printer.

2) Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts. Note: Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.
3) File Write: The ASCII File write reporting action shall enable the user to append user defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the user. The user may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
4) Write Property: The write property reporting action updates a property value in a hardware module.
5) SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.
6) Run External Program: The Run External Program reporting action launches specified program in response to an event.

j. There shall be 4 levels of alarm
1) Level 1: Life-safety message
2) Level 2: Critical equipment message
3) Level 3: Urgent message
4) Level 4: Normal message

k. Maintenance Mode. Operators shall have the ability to put any device in/out of maintenance mode.
1) All 1) All alarms associated with a device in maintenance mode will be suppressed except life safety alarms.
2) If a device is in maintenance mode, issue a daily Level 3 alarm at a scheduled time indicating that the device is still in maintenance mode.

l. Entry Delays. All alarms shall have an adjustable delay time such that the alarm is not triggered unless the alarm condition is TRUE for the delay time. Default entry delays are as follows:
1) Level 1 alarms: 1 seconds
2) Level 2 alarms: 10 seconds
3) Level 3 alarms: 1 minutes
4) Level 4 alarms: 5 minutes

m. Exit Hysteresis
1) Each alarm shall have an adjustable time-based hysteresis (default: 5 seconds) to exit the alarm. Once set, the alarm does not return to normal until the alarm conditions have ceased for the duration of the hysteresis.
2) Each analog alarm shall have an adjustable percent-of-limit-based hysteresis (default: 0% of the alarm threshold, i.e., no hysteresis; alarm exits at the same value as the alarm threshold) the alarmed variable required to exit the alarm. Alarm conditions have ceased when the alarmed variable is below the triggering threshold by the amount of the hysteresis.

n. Latching. Any alarm can be configured as latching or nonlatching. A latching alarm requires acknowledgment from the operators before it can return to normal, even if the exit deadband has been met. A nonlatching alarm does not require acknowledgment. Default latching status is as follows:
1) Level 1 alarms: latching
2) Level 2 alarms: latching
3) Level 3 alarms: nonlatching
4) Level 4 alarms: nonlatching

o. Postexist. Suppression Period. To limit alarms, any alarm may have an adjustable suppression period such that, if the alarm is triggered, its postsuppression timer is triggered and the alarm may not trigger again until the postsuppression timer has expired. Default suppression periods are as follows:
1) Level 1 alarms: 0 minutes
2) Level 2 alarms: 5 minutes
3) Level 3 alarms: 24 hours
4) Level 4 alarms: 7 days

p. For both latching and nonlatching alarms, the operators may acknowledge the alarm. Acknowledging an alarm clears the alarm, the exit deadband, and suppression period. A device can go right back into alarm as soon as the entry delay elapses.

LL. Trends: As system is engineered, all points shall be enabled to trend. Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.

1. Viewing Trends: The user shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.
2. Local Trends: Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers, and periodically uploaded to the BAS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.
3. Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for displays that have different trend intervals, the system will automatically scale the axis.
4. Dynamic Update. Trends shall be able to dynamically update at user-defined intervals.
5. Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and ' pan through' historical data by simply scrolling the mouse.
6. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.
7. Copy/Paste. The user shall have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).
8. Group Trend Time Series Plots
   a. Provide user-selectable Y points.
   b. Provide user-editable titles, point names, and Y axis titles.
   c. Individual trended points shall be able to be grouped in groups of up to four points per plot with up to four plots per page.
9. X-Y Trend Plots
   a. User- selectable X and Y trend inputs.
   b. User- editable titles, point names, and X and Y axis titles.
   c. User- selectable time period options:
      1) A 1-day 24-hour period;
      2) A 1-week 7-day period;
      3) A 1-month period, with appropriate days for the month selected; or (4) a 1-year period.
      4) The user shall be able to select the beginning and ending period for each X-Y chart, within the time domain of the database being used.
   d. User- selectable display of up to 6 plots per screen in 2 columns.

MM. Reports and Logs. Provide a reporting package that allows the operator to select, modify, or create reports. Each report shall be definable as to data content, format, interval, and date. Report data shall be archivable on the hard disk for historical reporting. Provide the ability for the operator to obtain real-time logs of all objects by type or status (e.g., alarm, lockout, normal). Reports and logs shall be stored on the Enterprise Server hard disk in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.

NN. Custom Reports. Provide the capability for the operator to easily define any system data into a daily, weekly, monthly, or annual report. Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common

algebraic calculations, and that present results in tabular or graphical format. These reports shall be time and date stamped and shall contain a report title and the name of the facility.

OO. Security Access: Systems that access from the web browser GUI to BAS server shall require a Login Name and Strong Password. Access to different areas of the BAS system shall be defined in terms of Role-Based Access Control privileges as specified:

1. Roles: Roles shall reflect the actual roles of different types of users. Each role shall comprise a set of ' easily understood English language' privileges. Roles shall be defined in terms of View, Edit and Function Privileges.
    a. View Privileges shall comprise: Navigation, Network, and Configuration Trees, Users, Roles and Privileges, Alarm/Event Template and Reporting Action.
    b. Edit Privileges shall comprise: Set point, Tuning and Logic, Manual Override, and Point Assignment Parameters.
    c. Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print and Alarm/Event Maintenance.

PP. Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same user defined HVAC Role) to different areas of the system.

QQ. 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.

RR. 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.

SS. Graphic Sequence: The clarity of the graphic sequence shall be such that the user 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 user with an understandable and exact representation of each sequence of operation.

TT. 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.

UU. 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.

2.6 BACnet Advanced Application Controller (B-AAC)

VV. General. Provide an adequate number of BACnet Advanced Application Controllers (B-AAC) to achieve the performance specified in the Part 1 Article on “System Performance”. B-AAC shall provide microprocessor based self-contained stand-alone fully programmable operation of local process control loops. The controller platform shall provide options and advanced system functions, programmable and configurable, that allow standard and customizable control solutions required in executing the "Sequence of Operation". All local level application programs shall be installed on individual controllers in non-volatile memory. Control systems that utilize ‘canned’ programs or programmable read only memory (PROM) level application programming are not acceptable. Each of these panels shall meet the following requirements.

1. The B-AAC shall have sufficient memory to support its operating system, database, and programming requirements.
2. Data shall be shared between networked B-AACs.
3. The operating system of the controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information, and allow central monitoring and alarms.
4. Controllers that perform scheduling shall have a real-time clock.
5. The B-AAC shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall
   a. Assume a predetermined failure mode,
   b. Generate an alarm notification.
6. The B-AAC shall communicate with other BACnet devices on the network using protocol specific services.
7. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals.
8. Provide documentation for each device, with the following information:
   a. BACnet Device; MAC address, name, type and instance number,
   b. BACnet Objects; name, type and instance number.

WW. Communication

1. Each B-AAC shall reside on a BACnet network using the MS/TP or Ethernet Data Link/ Physical layer protocol.

2. The controller shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable user's terminal.

XX. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at 32 degrees F to 150 degrees F and 10 to 90 percent RH.
2. Controllers used in conditioned space shall be mounted in dust proof enclosures, and shall be rated for operation at 32 degrees F to 120 degrees F.

YY. Keypad. A local keypad and display shall be provided for each controller. The keypad shall be provided for interrogating and editing data. An optional system security password shall be available to prevent unauthorized use of the keypad and display. If the manufacturer does not provide this keypad and display, provide a portable user terminal.

ZZ. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

AAA. Memory. The B-AAC shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

BBB. Immunity to power and noise. Controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 ft.

CCC. All control devices furnished with this Section shall be programmable directly from the Niagara 4 Workbench embedded toolset upon completion of this project. The use of configurable or programmable controllers that require additional software tools for post-installation maintenance shall not be acceptable.

2.7 BACnet Advanced Variable Air Volume Controller (B-AVAVC)

DDD. General. Provide an adequate number of BACnet Advanced Variable Air Volume Controller (B-AVAVC) to achieve the performance specified in the Part 1 Article on "System Performance". B-AVAVC shall provide microprocessor based self-contained stand-alone fully programmable operation of local process control loops. The controller platform shall provide options and advanced system functions, programmable and configurable, that allow standard and customizable control solutions required in executing the "Sequence of Operation". All local level application programs shall be installed on individual controllers in non-volatile memory. Control systems that utilize 'canned' programs or programmable read only memory (PROM) level application programming are not acceptable. Each of these controllers shall meet the following requirements.

1. The B-AVAVC shall have sufficient memory to support its operating system, database, and programming requirements.
2. Data shall be shared between networked B-AVAVCs.
3. The operating system of the controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information, and allow central monitoring and alarms.
4. Controllers that perform scheduling shall have a real-time clock.
5. The B-AVAVC shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
   a. Assume a predetermined failure mode,
   b. Generate an alarm notification.

6. The B-AVAVC shall communicate with other BACnet devices on the network using protocol specific services.
7. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals.
8. The controller shall have Significant Event Notification, Periodic Update capability and Failure Detect when network inputs fail to be detected within their configurable time frame.
9. Provide 9. Provide documentation for each device, with the following information:
    a. BACnet Device; MAC address, name, type and instance number,
    b. BACnet Objects; name, type and instance number.
    c. The controller shall have an internal velocity pressure sensor.
    d. The controller shall have an integrated or remote actuator.

EEE. Communication

1. Each B-AVAVC shall reside on a BACnet network using the MS/TP or Ethernet Data Link/ Physical layer protocol.
2. Each B-AVAVC shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable user's terminal.

FFF. Envionment. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 32 degrees F to 150 degrees F and 10 to 90 percent RH.
2. Controllers used in conditioned space shall be mounted in dust proof enclosures, and shall be rated for operation at 32 degrees F to 120 degrees F.

GGG. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

HHH. Memory. The B-AVAVC shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

III. Immunity to power and noise. Controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 ft.

JJJ. All control devices furnished with this Section shall be programmable directly from the Niagara 4 Workbench embedded toolset upon completion of this project. The use of configurable or programmable controllers that require additional software tools for post-installation maintenance shall not be acceptable.

2.8 BACnet Application Specific Controller (B-ASC)

KKK. General. BACnet Application Specific Controllers (B-ASCs) are microprocessor-based BAS controllers which through hardware or firmware design are dedicated to control a specific piece of equipment. They are not fully user-programmable, but are customized for operation within the confines of the equipment they are designed to serve. B-ASCs may not be used for complex sequences of operation. B-ASCs shall communicate with other BACnet devices on the network using the Read (Execute) Property service as defined in Clause 15.5 of ASHRAE Standard 135. Each B-ASCs shall be certified or listed for compliance to the BACnet standards.

1. Each B-ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network

2. Each B-ASC will contain sufficient I/O capacity to control the target system.
3. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals.
4. Provide documentation for each device, with the following information:
    a. BACnet Device; MAC address, name, type and instance number,
    b. BACnet Objects; name, type and instance number.

LLL. Communication

1. Each controller shall reside on a BACnet network using the MS/TP or Ethernet Data Link/ Physical layer protocol. Each network of controllers shall be connected to one building controller.
2. Each controller shall have a BACnet Data Link/Physical layer compatible connection for a laptop computer or a portable user's tool. This connection shall be extended to a space temperature sensor port where shown and allow access to the entire network.
3. Each controller shall have a secondary sub network for communicating sensors or I/O expansion modules.

MMM. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at 32 degrees F to 150 degrees F and 10 to 90 percent RH.
2. Controllers used in conditioned space shall be mounted in dust proof enclosures, and shall be rated for operation at 32 degrees F to 120 degrees F.

NNN. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

OOO. Memory. The application specific controller shall use nonvolatile memory and maintain all BIOS and programming information in the event of a power loss.

PPP. Immunity to power and noise. Controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 ft.

QQQ. Transformer. Power supply for the ASC must be rated at a minimum of 125 percent of ASC power consumption and shall be of the fused or current limiting type.

RRR. All control devices furnished with this Section shall be programmable directly from the Niagara 4 Workbench embedded toolset upon completion of this project. The use of configurable or programmable controllers that require additional software tools for post-installation maintenance shall not be acceptable.

2.9 MODBUS System Integration

SSS. The BAS shall support the integration of device data from MODBUS RTU, ACSII, or TCP control system devices. The connection to the MODBUS system shall be via an RS-232, RS485, or Ethernet IP as required by the device.

1. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of the MODBUS system data into the FPMS. Objects provided shall include at a minimum:
2. Read/Write MODBUS AI Registers
3. Read/Write MODBUS AO Registers

4. Read/Write MODBUS BI Registers
5. Read/Write MODBUS BO Registers

TTT. All scheduling, alarming, logging and global supervisory control functions, of the MODBUS system devices, shall be performed by the Network Area Controller.

UUU. The BAS supplier shall provide a MODBUS system communications driver. The equipment system vendor that provided the equipment utilizing MODBUS shall provide documentation of the system's MODBUS interface and shall provide factory support at no charge during system commissioning.

2.10 Input/Output Interface

VVV. Hardwired inputs and outputs may tie into the BAS through building, advanced application, or application specific controllers.

WWW. All input and output points shall be protected such that shorting of the point to itself, to another point, or to ground, shall cause no damage to the controller. All input and output points shall be protected from voltage up to 24 volts of any duration, such that contact with this voltage will cause no damage to the controller.

XXX. Binary inputs shall allow the monitoring of ON/OFF signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.

YYY. Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.

ZZZ. Analog inputs shall allow the monitoring of low-voltage (0-10 VDC), current (4-20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with – and field configurable to – commonly available sensing devices.

AAAA. Binary outputs shall provide for ON/OFF operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and advanced application controllers shall have three-position (On/Off/Auto) override switches, and status lights. Outputs shall be selectable for either normally open or normally closed operation.

BBBB. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC signal or a 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs on building or advanced application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4 percent of range per year.

CCCC. Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct mounted heating coils, zone dampers, radiation, etc.) Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of user tracking.

DDDD. Input/Output points shall be universal type, i.e., controller input or output may be designated (in software) as either a binary or analog type point with appropriate properties. Application specific controllers are exempted from this requirement.

EEEE. System Capacity. The system size shall be expandable to at least twice the number of input/output objects/points required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The user interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

FFFF. Each controlled device or function shall be a separate output of the digital controller (i.e., Economizer, Heating Valve, Cooling Valve are three (3) separate output points). When a points' list is provided the greater number of points and their configuration shall govern. Multiplexers or programmable logic controllers utilized with digital controller input and output points to expend the digital controller I/O capabilities will not be allowed.

PART 3 - EXECUTION

3.1 Pre-Installation Sequences of Operations Meeting

A. Prior to shop drawings submittals and any hardware installation, set-up and conduct a “Sequences of Operations” meeting to review the specified sequences to confirm an understanding of intent. Invited attendees shall include the BAS software programming technicians, Owner’s representative(s), Construction Manager, and Engineer of Record. Coordinate with Construction Manager.

3.2 Examination

B. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the Engineer for resolution before rough-in work is started.

C. Inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the Engineer for resolution before rough-in work is started.

D. Examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate or if any discrepancies occur between the plans and the Contractor’s work and the plans and the work of others, then report these discrepancies to the Engineer and obtain written instructions for any changes necessary to accommodate the temperature control work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect to report such discrepancies shall be made by and the costs borne by this Contractor.

3.3 Protection

E. Protect all work and material from damage by their work or employees, and shall be liable for all damage thus caused.

F. The installing contractor shall be responsible for their work and equipment until finally inspected, tested, and accepted. Protect any material that is not immediately installed. Close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.4 Coordination

G. Site

1. Where the temperature control work will be installed in close proximity to, or will interfere with work of other trades, assist in working out space conditions to make a satisfactory adjustment. If temperature control work is installed before coordinating with other trades,

so as to cause any interference with work of other trades, the temperature control work shall be re-worked to correct the condition without extra charge.
2. Coordinate and schedule work with all other work in the same area, or with work which is dependent upon other work, to facilitate mutual progress.

H. Test and Balance

1. Furnish all tools necessary to interface to the control system for test and balance purposes.
2. Provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
3. In addition provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.

I. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated as follows:

1. All communication media and equipment shall be provided as specified in Part 2: “Communication” of this specification.
2. Each supplier of controls product is responsible for the configuration, programming, start-up, and testing of that product to meet the sequences of operation described in this section.
3. Coordinate and resolve any incompatibility issues that arise between the control products provided under this Section and those provided under other sections or divisions of this specification.

J. Revise equipment tagging and nomenclature, room numbering, etc. to reflect as-built conditions or an Owner’s preference for integration into their existing naming numbering convention.

3.5 Field Quality Control

K. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this specification.

L. Continually monitor the field installation for code compliance and quality of workmanship.

M. Have work inspected by authorities having jurisdiction over the work.

3.6 Controllers

N. Provide a separate controller for each AHU, terminal unit, fan coil, and other unitary equipment and HVAC systems. A DDC controller may control more than one system provided that all points/objects associated with the system are assigned to the same DDC controller. Points/objects used for control loop reset such as outside air or space temperature are exempt from this requirement.

O. Building Controllers and Custom Application Controllers shall be selected to provide a minimum of 15 percent spare I/O point/object capacity for each point/object type found at each location. If input /objects are not universal, 15 percent of each type is required. If outputs are not universal, 15 percent of each type is required. A minimum of one spare is required for each type of point/object used.

1. Future use of spare capacity shall require providing the field device, field wiring, point/object database definition, and custom software. No additional controller boards or point/object modules shall be required to implement use of these spare points.

3.7 Programming

P. Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25 percent of available memory free for future use.

Q. Point/object Naming: System point/object names shall be modular in design, allowing easy user interface without the use of a written point/object index. Use the following naming convention:
AAABBBCCCDDDEEE where:

AAA is used to designate the location of the point/object within the building such as mechanical room, wing, or level, or the building itself in a multi-building environment.

BBB is used to designate the mechanical system with which the point/object is associated (e.g., A01, HTG, CLG, LTG).

CCC represents the equipment or material referenced (e.g., SAF for supply air fan, EXF for exhaust fan, RAF for return air fan).

D or DD or DDD may be used for clarification or for identification if more than one of CCC exists (e.g., SAF10, EXF121).

EE represents the action or state of the equipment or medium (e.g., T for temperature, RH for humidity, CO for control, S for status, D for damper control, I for current).

R. Software Programming

1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:
   a. Text-based:
      1) must provide actions for all possible situations
      2) must be modular and structured
      3) must be commented
   b. Graphic-based
      1) must provide actions for all possible situations
      2) must be documented
   c. Parameter-based
      1) must provide actions for all possible situations
      2) must be documented
2. After submittal and review of control software, offer to schedule a meeting with the Engineer and Commissioning Agent (CxA) to review system function.

S. Graphical User Interface

1. Standard Graphics. Provide graphics for all controlled systems and floor plans of the building. Point/object information on the graphic displays shall dynamically update. Show on each graphic all input and output points/objects for the system. Also show relevant calculated points/objects such as setpoints.
2. Show terminal equipment information on a “graphic” summary table. Provide dynamic information for each point/object show.

3. Provide all the labor necessary to install, initialize, start up, and troubleshoot all user interface software and their functions as described in this section. This includes any operating system software, the user interface database, and any third-party software installation and integration required for successful operation of the user interface.
4. Provide graphic representation of each system. Graphic shall have a link to its respective approved as-built sequence of operation in portable document format (pdf) or hypertext markup language format (html).
5. Provide graphic representation of each control device component (sensor, controller, controlled device). Each control device component graphic representation shall have a cursor-hover-over pull-down box with links to the manufacturer's data sheet, installation instructions, maintenance instructions, and programming instructions literature in portable document format (pdf) or hypertext markup language format (html). Also, provide a link to an active trend of sensor and controlled device components.
6. Provide graphic representation of each equipment component (pump, boiler, chiller, air handling unit, etc.). Each equipment component shall have a cursor-hover-over pull-down box with links to the manufacturer's data sheet, installation, maintenance, and programming literature in portable document format (pdf) or hypertext markup language format (html). For equipment components with factory mounted controllers provide an additional link to a graphic representation of all equipment controller data available via the respective communication protocol interface in tabular format.
7. The BAS Contractor shall initially prepare and be responsible for a Graphical User Interface Development Plan. The plan shall describe the process for the development of the GUI.
8. GUI Scope Meeting: Within 45 days from execution of the Contract, participate in a scope meeting with the GUI Development Team chaired by the BAS Contractor. The purpose of the meeting includes a review of the GUI Development Plan with discussions of development schedule, graphical requirements, and assignments of responsibilities.
9. GUI Coordination Meetings: The GUI Development Team members will meet on a predetermined and approved basis (by the Owner) to review progress on the GUI work, coordinate scheduling conflicts, and to discuss strategies and processes for upcoming tasks. The meetings will be chaired by the BAS Contractor. Allow for 80 hours of meeting time.
10. GUI Development Meeting Minutes: The BAS Contractor shall prepare minutes of the initial scope and progress meetings, and shall include a copy of the agenda, and identify location and date of the meeting, and individuals in attendance. Minutes shall be distributed to members of the GUI Development Team.
11. GUI Development Team: Members of the GUI Development Team shall include, but not be limited to the Owner, BAS Contractor, and such parties designated by the Owner or BAS Contractor.

3.8 Control System Checkout and Testing

T. Start-up Testing: All testing listed in this article shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Owner's Representative is notified of the system demonstration.

1. Upon completion of the control system, adjust all components of the system. Make all adjustments in the control system required and as directed by the balancer to achieve the desired air balance quantities. All instruments shall be carefully calibrated and each control function shall be demonstrated to function properly, to the satisfaction of the Engineer and the Owner. Provide a complete instruction manual covering the function and operation of all components. At the time of demonstration, each function shall be simulated to ensure that controls respond properly to all signals, and the Owner shall be instructed in the proper operation of the system.
2. Furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
3. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.

4. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures per manufacturers' recommendations.
5. Verify that all binary output devices (relays, solenoid valves, two position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
6. Verify that all analog output devices (transducers, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. Check all control valves and automatic dampers to ensure proper action and closure. Make any necessary adjustments to valve stem and damper blade travel.
7. Verify that the system operation adheres to the Sequences of Operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum Start/Stop routines.
8. Alarms and Interlocks
    a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
    b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
    c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.
9. Each unit and associated controls, safeties and wiring shall be checked out, started and adjusted by a factory trained service technician. Submit a startup report including a list of all unit safety and control settings, whether fixed or adjustable, as field checked and setup per the specified design conditions five days after unit startup. Submit service technician certification upon request.

3.9 Control System Demonstration and Acceptance

U. Demonstration

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the temperature controls have been completed, started up and performed its own tests.
2. The tests described in this section are to be performed in addition to the tests that are performed as a necessary part of the installation, startup, and debugging process and as specified in the "Control System Checkout and Testing" Article in Part 3 of this specification. The Engineer may be present to observe and review these tests. The Engineer shall be notified at least 10 days in advance of the start of the testing procedures.
3. The demonstration process shall follow that approved in Part 1: "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.
4. Provide at least two persons equipped with two way communication, and demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point/object and system. Provide and operate any test equipment required to prove the proper operation.
5. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
6. Demonstrate compliance with Part 1: "System Performance.
7. Demonstrate compliance with Sequences of Operation through all modes of operation.
8. Demonstrate complete operation of User Interface.
9. Additionally, the following items shall be demonstrated:
    a. DDC Loop Response. Supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in setpoint, which represents a change of actuator position of at least 25 percent of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each

sample the setpoint, actuator position, and controlled variable values. Further tune any loop that yields unreasonably under-damped or over-damped control.

b. Optimum Start. Supply a trend data output showing the capability of the algorithm. The hour by hour trends shall include the output status of all optimally started equipment, as well as temperature sensor inputs of affected areas.

c. Interface to the building fire alarm system.

d. Operational logs for each system that indicate all setpoints, operating points, valve positions, mode, and equipment status shall be submitted to the Engineer. These logs shall cover three 48 hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.

10. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date, and any necessary repairs or revisions to the hardware or software to successfully complete all tests shall be made.

V. Acceptance

1. All tests described in this specification shall have been performed to the satisfaction of both the Engineer and Owner prior to the acceptance of the control system as meeting the requirements of Completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the Completion requirements if stated as such in writing by the Engineer. Such tests shall then be performed as part of the warranty.
2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1: Submittals.

W. During the first year of operation, after acceptance by the Owner, provide complete service to adjust or assist the Owner in adjusting the equipment to obtain optimum performance from the control equipment and from the heating and air conditioning systems in general. This shall be done without additional expense to the Owner. This work shall include revisions to DDC software programs and controller, and all PC front end software upgrades. All software shall be provided to the Owner in disk form, including back-ups of final field programs.

3.10 Cleaning

X. Clean up all debris resulting from its activities daily. Remove all cartons, containers, crates, etc., under its control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

Y. At the completion of work in any area, clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

Z. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.11 Training

AA. Provide a minimum of three onsite training classes 8 hours in length during the construction period for personnel designated by the owner.

BB. Provide two additional training sessions at 6 and 12 months following building's turnover. Each session shall be 8 hrs. in length and must be coordinated with the building Owner.

CC. Train the designated staff of Owner's Representative and Owner to enable them to:

1. Day-to-day Users:
   a. Proficiently operate the system

b. Understand control system architecture and configuration
c. Understand DDC system components
d. Understand system operation, including DDC system control and optimizing routines (algorithms)
e. Operate the user interface and peripherals
f. Log on and off the system
g. Access graphics, point/object reports, and logs
h. Adjust and change system setpoints, time schedules, and holiday schedules
i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
j. Understand system drawings, and Operation and Maintenance manual
k. Understand the job layout and location of control components
l. Access data from DDC controllers
m. Operate portable user's terminals

2. Advanced Users:
   a. Make and change graphics on the user interface
   b. Create, delete, and modify alarms, including annunciation and routing of these
   c. Create, delete, and modify point/object trend logs, and graph or print these
   d. Create, delete, and modify reports
   e. Add, remove, and modify system's physical points/objects
   f. Create, modify, and delete programming
   g. Add panels when required
   h. Add user interface stations
   i. Create, delete, and modify system displays — both graphical and otherwise
   j. Perform BAS system field checkout procedures
   k. Perform DDC controller unit operation and maintenance procedures
   l. Perform user interface and peripheral operation and maintenance procedures
   m. Perform BAS system diagnostic procedures
   n. Configure hardware including PC boards, switches, communication, and I/O points/objects
   o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware
   p. Adjust, calibrate, and replace system components
3. System Managers/Administrators:
   a. Maintain software and prepare backups
   b. Interface with job-specific, third-party user software
   c. Add new users and understand password security procedures

DD. Provide course outline and materials as per "Submittals" Article in Part 1 of this specification. The instructor(s) shall provide one copy of training material per student.

EE. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

FF. Classroom training shall be done using a network of working controllers representative of the installed hardware.

3.12 Outdoor temperature and humidity sensors shall be mounted on the north face of the building unless otherwise approved by the Engineer.

3.13 In addition to the adjustments and fine tuning, include as a part of this contract the equivalent of five (5) man days of service technician and/or programming time for work as may be specified by the Engineer.

END OF SECTION

23 73 00 MODULAR AIR HANDLING UNITS

PART 1 - GENERAL

1.1 This specification shall apply to the following air handling units with interior type unit construction: AC-H-1, AC-H-2, AC-H-3, and AC-H-4.

1.2 Air handling units shall be factory assembled with double wall casing and components and features as herein specified. Refer to the drawings for configuration, size, capacities and other characteristics.

1.3 Fan shall be constructed, rated and labeled in accordance with AMCA Standard 210 and AMCA 300. Fans shall be statically and dynamically balanced throughout the operating range. The class of the fan provided shall be adequate for the duty specified plus a 25 percent increase in static pressure. Shop drawing submittals shall state maximum fan RPM for fan class provided. No infringement will be allowed on this requirement. Shop drawings shall include, in addition to normal descriptive information (sizing, capacity data, etc.), fan curves showing operating points (including increased static pressure), system curves, surge lines, fan bearing description and belt and drive information.

1.4 Coils performance shall be certified in accordance with AHRI Standard 410 for coil capacity and pressure drop. Coils which cannot be certified because they are outside the range of AHRI's standard rating conditions shall be rated in accordance with AHRI Standard 410. Coils shall be factory tested to minimum 300 PSIG compressed air under water. Dehydrate and seal coils prior to shipping.

1.5 The Contractor and the unit supplier shall check plans carefully before bidding and again in the preparation and review of shop drawings to ensure that space available accommodates the proposed equipment in a manner to be accessible for service and components removal and replacement. Give special consideration to removal and replacement of filters, coils and other components.

1.6 Dynamic fan balancing for air handling units used with variable speed drives or ECMs shall be done throughout the variable speed operating range of the fan.

1.7 Refer to specification sections 23 05 13 Electrical Requirements for HVAC Equipment, 23 05 14 Adjustable Frequency Motor Controller, 23 41 02 Photocatalytic Oxidation Unit, for associated Requirements.

1.8 Refer to Section 23 05 49 Vibration Control for HVAC for vibration isolator types.

1.9 Dampers shall be tested and licensed for air performance and leakage in accordance with ANSI/AMCA standard 500-D and AMCA publication 511.

1.10 Seal openings to protect against damage during shipping, handling, and storage. Wrap equipment, including electrical components, for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust, and corrosion. Keep equipment clean and dry. Prior to shipping wrap indoor units with a tight sealing membrane. Wrapping membrane shall cover the entire unit during shipping and storage. Tarp outdoor units to protect against rain and road debris during shipping.

1.11 Mechanical equipment, appliances and supports that are exposed to wind shall be designed and installed to resist the wind speed determined in accordance with the building and mechanical code. Refer to specification 23 05 30 Bases and Supports for HVAC Equipment for additional requirements. Note that 23 05 30 requires that Compliance be proven at time of submittals with a wind certification performed by a licensed professional engineer.

1.12 Equipment shall carry an all-inclusive manufacturer's parts and labor warranty for a period of five (5) years from date of final acceptance or date of beneficial use, as agreed to between Contractor and Architect or Construction Manager. Any materials, equipment, or controls found to be defective during this warranty period shall be made good without expense to the Owner, including any required

replacement of fluids, glycol or refrigerant. The warranty shall include a delayed start-up provision such that the warranty does not begin at time of delivery. The labor for the warranty shall be performed by the manufacturer's authorized service agent.

PART 2 - PRODUCTS

2.1 Casings to house the various unit components (including floor and interior partitions) shall be double wall sheet metal; minimum 24 gauge outer and 24 gauge inner walls with foam insulation between the panels, framing and reinforcing. Casings shall be of a modular design with 2 inch thick panels with solid metal sheet both outside and inside, except where perforated inside liner is noted. Sections shall have bolted intervening connections. Casings and parts shall be galvanized sheet steel throughout or sheet steel chemically cleaned, phosphatized and painted on the exterior with enamel.

A. Insulation shall be 2-inch-thick 1.50 lb. density polyurethane foam. Insulation and adhesive shall meet 25-50 rating in accordance with NFPA 255 test methods. Insulation shall have minimum thermal resistance of R-13, with a resistance to mold growth in accordance with UL 181 or ASTM C1338. Application of insulation shall conform with requirements of NFPA 90A.

B. Access doors shall be provided in the fan sections, access sections and where otherwise shown. Doors shall be 18 inches wide minimum x 60 inches high when sufficient height is available, or the maximum height allowed by the unit, if not otherwise sized. Doors shall be double wall insulated with vision glass and have heavy duty hinges, quarter turn heavy duty latches with handle (sash type not acceptable) and gasketing. Each door shall have a minimum of two latch points. Latch points more than 5 feet above the roof or floor level shall include linkage to a handle that is no higher than 5 feet above the roof or floor level so that all linked latches engage and disengage from the movement of one handle. All doors shall include a gasketed test port for instrument insertion into the air stream and have individual gutters. Vision glass shall be double pane non-condensing. Minimum window dimension shall be 8" x 8" or equivalent round dimension.

C. The cabinet unit casing (wall/floor/roof panels and doors) shall be constructed and tested to withstand both positive and negative 8 inches w.g. pressure, relative to atmospheric pressure, and shall not exceed 0.0042 inches per inch of panel span (L/240) at the 8 inch differential. All assembly hardware shall be consistent with the basic construction material type.

D. Treadplate shall be applied to the unit floor to improve the walking surface in those unit sections where the floor is fully accessible, and not impeded by internal structural or functional features, such as drain pans. Treadplates shall be aluminum or stainless steel material. Treadplates are not required for units with inside clear height dimension of 48" or less.

E. A drain pan shall be incorporated in sections containing cooling coils, heating coils, in the first section downstream of the cooling, in access sections between coils and in other sections so noted on the drawings. Drain pan shall be double wall with insulation between. Interior liner shall be stainless steel for those sections with cooling coils. Others shall be galvanized steel. Drain pan shall be sloped in two directions and shall have a tapped drain outlet at that side of the pan extending a minimum of 6 inches downstream of coil face. Drain pan shall be a full compliance with ASHRAE 62.1. Units with stacked coils shall have intermediate drain pans to collect condensate from each coil.

F. Unit casing shall conform to ASHRAE Standard 111 Leakage Class 6 at 1.20 times the design static pressure(not to exceed the rated cabinet pressure). Refer to SMACNA.HVAC Duct Leakage Test Manual for leakage testing procedure. Confirm test procedure with the Engineer before performing test. Notify Construction Manager and design team a week before AHU leakage test is performed.

G. Duct connections to the unit shall be bell mouth type openings.

H. The base rail of the unit shall be constructed of all welded structural steel channel or I-beam, minimum 8 inches high. Integral lifting lugs shall be provided. The base rail shall be protected with corrosion resistant coating or finish. All assembly hardware shall be consistent with the basic construction material type.

2.2 Each section with an access door shall be provided with one or more marine lights, with a GFI receptacle in the supply fan section. Lights shall be instant-on, white light, LED type to minimize amperage draw and shall produce 1200 lumens. Light fixture shall be weather-resistant, enclosed and gasketed to prevent water and dust intrusion. All lights in the unit shall be wired in the factory to a single junction box and on-off switch mounted on the exterior of the cabinet. All receptacles on the unit shall be wired in the factory to a separate junction box mounted on the exterior of the cabinet. Power to each junction box shall be 120V single phase and coordinated with Division 26.

2.3 Interior units shall be mounted as follows:

A. Each unit(s) shall be mounted on concrete housekeeping pad, refer to 23 05 30 Bases and Supports for HVAC Equipment for requirements.

2.4 Fan section shall contain fan(s), motor(s), drive components and accessories. Motor and drive shall be mounted within the casing and internally isolated. Fan assembly shall consist of:

B. Supply shall be direct drive plenum fans and shall consist of a direct driven arrangement of four plenum fans in a 2 x 2 array, constructed per AMCA requirements for the duty specified. All fans shall be selected to collectively deliver the specified airflow quantity at the specified operating total static pressure and specified fan/motor speed. The fan system shall be selected to operate at a system total static pressure that does not exceed 85% of the specified fan's peak static pressure producing capability under stable operation at the selected fan/motor speed. A wire fan guard shall be provided at the inlet and around the discharge side of each fan. Fan bearings shall be permanently sealed with life-time lubrication pillow block type self-aligning ball or roller bearings, 250,000 hour L10 average rated life. A supporting framework shall be incorporated to mount the fan wheels and bearings and the motor base. All wheels shall be statically and dynamically balanced throughout the operating range on precision electronic balancers to a level of G6.3 (per ANSI 2-19) or better and shall be factory tested for vibration and isolation. When recommended by fan manufacturer include a solid sheetmetal baffle between fans in the fan array to minimize interference between fans. Each fan/motor assembly shall be dynamically balanced and vibration isolated. Direct-drive fan sections shall use 2-pole (3600 rpm), 4-pole (1800 rpm), or 6-pole (1200 rpm) NEMA Design B. Multiple fan selections utilizing 8-pole (900 rpm) motors are unacceptable due to motor inefficiency, cost, and replacement lead times.

C. Walk-in access shall be provided both upstream and downstream of. Provide a a blank off plate that prevents the circulation of air from the discharge side of the fan array to the suction side of the fan array shall be provided for isolating each fan (and mounting hardware at each fan inlet).

D. Motor(s) shall be "premium efficiency" series. Motors connected to VFD's shall comply with 23 05 13 Electrical Requirements for HVAC Equipment and shall be furnished with AEGIS SGR shaft grounding ring kit, installed by the equipment manufacturer. Refer to Section 23 05 13 Electrical Requirements for HVAC Equipment. All motors shall be standard pedestal mounted type, ODP / TEFC motors selected at the specified operating voltage, and shall be inverter duty. All motors shall include isolated bearings or shaft grounding. Power wiring run in conduit and comply with the N.E.C., including flexible type at motor connections.

Fan motor operating Hz shall be selected to not exceed 60 Hz at the specified design cfm and static pressure.

E. Although no test is required, fan array layouts shall be designed to produce a uniform air flow profile and velocity profile within the airway tunnel of the air handling unit not to exceed the specified cooling coil and/or filter bank face velocity when measured at a point 12 inches from

the intake side of the fan intake plenum wall, and at a distance of 36 inches from the discharge side of the fan. Each fan/motor assembly shall be removable through a 30 inches wide, free area, access door. The motor base shall be fastened securely to the structural steel framing of the fan assembly.

F. Vibration isolation of the fan and motor assembly shall be internal to the fan casing. Vibration isolators shall Type C1, per specification 23 05 49 Vibration Control for HVAC.

2.5 Unit shall be provided with coil connections that extend a minimum of 5" beyond unit casing. Drain and vent connections shall be extended or provided on the exterior of the unit casing. Vent connections shall be provided at the highest point to ensure proper venting and all piping shall slope to drain connections provided at the lowest point to ensure complete drainage. Coil connections shall be factory sealed, and with gasket sleeve between outer wall and liner where each pipe extends through the unit casing to minimize air leakage and condensation inside panel assembly. The number of coil connections for each coil bank shall match the unit piping detail on the drawings unless otherwise approved by the Engineer. Coils shall be removable through the side of the unit and as indicated on the drawings without the need to remove and disassemble the entire section from the unit. Provide a minimum of 18" intervening access space between multiple finned-tube coils in series. Coil sections shall be:

A. Preheat coil and heating coil shall be hot water type with minimum 1/2 inch seamless copper tubes with 0.032 inch minimum wall thickness, aluminum fins, supply and return headers and galvanized steel frame. U-bend coil pipes and header connections shall be silver-brazed or TIG welded. Water velocity through the heating coil shall be minimum 3 fps and maximum 5 fps at design flow rate.

B. Cooling coil shall be chilled water type with minimum 1/2 inch seamless copper tubes with 0.32 inch wall thickness, aluminum fins, supply and return headers and galvanized steel frame. U-bend coil pipes and header connections shall be silver-brazed or TIG welded. Water velocity through the coil shall be maximum 5 fps at design flow rate. Maximum dry-coil air pressure drop at 500 fpm face velocity shall be 0.75 in. w.c. in accordance with ASHRAE 62.1 requirements, shop drawing submittals shall provide the information showing compliance with this requirement.

2.6 Filter sections shall consist of a casing section with access door on each side and gasketed side access filter racks. Filter banks shall be as shown on the drawings and filter types, efficiencies, and quantities shall be provided equal to those scheduled on the drawings, refer to Section 23 41 00 Air Filters. Maximum filter face velocity shall be 500 fpm.

A. For units utilized during construction, at each filter bank provide one complete initial set of filters for that use. Immediately prior to balancing, commissioning, and substantial completion for handover to the owner, provide a complete set of new filters at each filter bank. In addition, furnish a complete set of new filters as a spare for the Owner's use. All filters used and furnished shall be as specified.

B. Pressure differential gauges equal to Dwyer "Magnehelic" Series 2000 dial type gauge shall be factory mounted at each HEPA filter and at each filter rated MERV 8 or higher. Range shall be appropriate for the application. Each gauge shall be furnished with vent valves, aluminum or plastic tubing, and static pressure tips.

2.7 Photocatalytic air cleaning units sections shall be provided immediately downstream of the cooling coil. Coordinate with PCO system manufacturer to ensure adequate space is provided to meet UVGI system requirements. Refer to specification 23 41 02 Photocatalytic Oxidation Unit.

2.8 Mixing box shall consist of a casing with outside air dampers, and return air dampers as shown on the drawings and described below.

C. Arrangement of outside air dampers and return air dampers shall be opposed blade. Dampers shall be aluminum air foil blades equipped with external linkage for automatic control, vinyl or EPDM blade edge seals and metal compressible jamb seals. AMCA certified. All outside air and relief air dampers shall be thermally insulated Tamco 9000 SC Series with internal foam insulation and thermally broken, or equal by Ruskin or Greenheck with a maximum leakage rate of 8 CFM/SF at 4 inch w.g. differential pressure. Return air and other control dampers shall be Tamco 1000 Series or equal by Ruskin or Greenheck with a maximum leakage rate of 8 CFM/SF at 4 inches w.g. differential pressure. Maximum blade length shall be 60 inches. Mixing box and panel filter section may be combined into a single section only where specifically indicated on the drawings. Provide access doors as indicated on the drawings or as required for damper access. Refer to Section 23 09 25 Instrumentation and Control Devices for HVAC.

D. Unless noted otherwise on the drawings, dampers shall be sized based on the following requirements:

1. Outside air damper shall be sized based on unit supply CFM at 1000 fpm.

2. Return air dampers shall be sized based on unit supply CFM minus minimum outside air CFM. The pressure drop across the return air damper shall be between 90%-110% of the sum of the pressure drops of the relief air damper plus the minimum outside air damper. The mixing box dampers shall be installed and sized to encourage good mixing of the outside and return air streams by the following measures:
   a. The largest dimension (height or width) of the return air damper shall match the respective largest dimension of the outside air damper.
   b. The return air damper shall be mounted as close to the outside air damper as possible.

2.9 Units shall be manufactured by Trane, Daikin, JCI, Temtrol or approved equal.

2.10 Air Handling unit accessories that are to be provided by the contractor and field installed, and that the air handling unit manufacturer shall coordinate with are:

A. Variable frequency drives. Refer to Section 23 05 14 Adjustable Frequency Motor controllers.

PART 3 - EXECUTION

3.1 Units shall be rigged and installed in accordance with manufacturer's instructions.

3.2 Manufacturer shall perform a field leakage test conforming to ASHRAE Standard 111 test to confirm the unit meets specified requirements stated in part 2. Manufacturer shall provide a written statement confirming that the unit is built to the manufacturer's factory standards and that the unit will carry the full warranty.

3.3 Each interior base-mounted unit shall be mounted concrete housekeeping pad as shown on the drawings. Coordinate location and dimensions of the unit and mounting elements with other trades.

If required to attain adequate height above the floor for proper installation of condensate drain piping and associated trap, additional steel beams or back-to-back channels with rust inhibiting paint coating shall be provided under the unit. Refer to the condensate drain piping details on the drawing for height requirements.

3.4 All power wiring shall be run in conduit and comply with the N.E.C., including flexible type at motor connections.

3.5 Provide condensate drain piping with a deep trap, per details on the drawings, from the drain pan to the designated discharge point.

3.6 AHU's shall be positioned such that there is the required minimum straight length of duct for the outside air airflow measurement stations. This shall be reviewed during bidding and the appropriate airflow station selected that meets the application.

END OF SECTION