ADDENDUM

Addendum No.: **3**
Date: 02/20/2019
Contract No.: 54015
Project: Atherton Civic Center
Location: 80 Fair Oaks Lane
Application No.: TBD
WRNS Project No: 15007.00
WRNS File No: 9.2

This Addendum will become part of the Contract Documents. In case of difference with previous addenda or communications, this addendum takes precedence. It is the responsibility of the Contractor to notify all sub-contractors from whom he accepts bids for all changes in the drawings and specifications covering this project. Receipt shall be acknowledged by inserting the Addendum number and its date in the bid form.

REVISIONS/CLARIFICATIONS TO THE PROJECT MANUAL

1. GENERAL:
   a. Reissued Specification Sections: The following specifications are modified as herein described. Specifications being re-issued with changes incorporated are indicated as (attached).

2. SECTION 10 2239 – FOLDING PANEL PARTITIONS
   a. Add paragraph 2.2 F as follows and renumber subsequent paragraphs.

      F. NIC: Not less than 42.

3. SECTION 23 0900 Instrumentation and Control Performance Specifications
   a. Add sub-paragraph 3.8 T.7. Heat Pump Freeze Protection Mode: and renumber subsequent sub-paragraphs, per attached specification Section 23 0900.

4. SECTION 23 2116 Hydronic Piping Specialties
   a. Delete Glycol System from specification section per attached specification Section 23 2116.

5. SECTION 23 6400 Heat Recovery Heat Pump
   a. Add sub-paragraph 2.1 B. per attached specification Section 23 6400.
   b. Add sub-paragraph 2.2 M.9. per attached specification Section 23 6400.

REVISIONS/CLARIFICATIONS TO THE DRAWINGS

1. GENERAL
   a. Reissued Drawings: The following drawings are modified as herein described. Drawings are indicated as (attached) or (not attached).

Drawings not included at this time will be reissued at full scale in conformance set prior to beginning of construction.

1. Sheet L5.02 Planting Plan
   a. Plan: Revise plan per attached drawing L5.02
2. Sheet M-003 Library – Schedules - Mechanical
   a. Plan: Revise plan per attached drawing M-003.
3. Sheet M-201 City Hall – Level 1 Floor Plan – Mechanical
   a. Revise per attached drawing M-201.
4. Sheet M-202 City Hall – Level 2 Floor Plan – Mechanical
   a. Revise per attached drawing M-202.
5. Sheet M-211 Library/Town Hall – Level 1 Floor Plan – Mechanical
   a. Revise per attached drawing M-211.
6. Sheet M-402 City Hall – Enlarged Plans and Sections – Mechanical
   a. Revise per attached drawing M-402.
7. Sheet M-411 Library – Enlarged Plans and Sections – Mechanical
   a. Revise per attached drawing M-411.
8. Sheet M-502 Piping Diagrams – Mechanical
   a. Revise detail 2 per attached drawing M-502.
9. Sheet M-601 Details – Mechanical
   a. Revise detail 4 per attached drawing M-601.
10. Sheet M-603 Details – Mechanical
    a. Revise detail 4 per attached drawing M-603.
11. Sheet M-702 Control Diagrams – Mechanical
    a. Revise detail 5 per attached drawing M-702.
12. Sheet E-003 Luminaire Schedule
    a. Revise schedule per attached drawing E-003.
13. Sheet E-711 Details – Electrical
    a. Revise detail 3 per attached drawing E-711.
    b. Add detail 6 per attached drawing E-711.

2. Sheet C-311 Cal Water Main Profile
   a. Revise note 2 to read as follows:

      "Contractor will be responsible for scheduling installation of the water main with Cal Water and coordinating all inspections of work in the vicinity of Cal Water facilities that may require the agency's approval and/or oversight."

3. Sheet C-400 Details
   a. See attached sketch CSK-001.

4. Sheet A-601 Interior Partition Schedule
   a. Add note to PARTITION TAG:

      <u>Acoustic Partition</u>
      At acoustic double stud partitions, brace laterally per detail 5/A-602. Do NOT brace to parallel stud wall.

5. Sheet A-701 Door Schedule, Frames & Types
    a. Doors CD.1, CD.8 & CS.3: Add sill detail 16/A-702.

6. Sheet A-722 Library Interior Window Schedule & Details
    a. Details 3 and 7: Add 2 ½" acoustic batt above fabric ceiling in Meeting Rooms and Copy Center per attached ASK-008.
    b. Coordinate mechanical opening above Acoustic Wood Wall Panels, per attached sketch ASK-008.

7. Sheet A8.41 Exterior Window Schedule
    a. Window Type B7: Add "Level-3" to frame.

8. Sheet AI-001 Interior Finish & Material Schedule
    a. Revise PTF-1 as follows:

Description:	Porcelain Floor Tile City Hall Lobby Restrooms
Manufacturer:	-**Terratinta Ceramiche**
Product;	-Bentongreys
Color:	-**Marrakech Warm – Anna**
Size:	-8"x8"
Grout:	-
Grout Color:	TBD
Rep:	-

9. Sheet M-212 Library/Town Hall – Roof Plan – Mechanical
    a. Revise callout for L-EF-1, from 1/M-603 to "4/M-601".

Prepared by:
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WRNS STUDIO
February 20, 2019

SPECIFICATIONS

SECTION 23 0900

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:
1. Communications
2. Operator Interface
3. Controller Software
4. Web Based Access
5. BAS Graphics
6. Building Controllers
7. Application Specific Controllers
8. Advanced Application Controllers
9. Application Specific Controller - Terminal Unit Controllers
10. Input/Output Interface
11. Power Supplies and Line Filtering
12. Control Panels
13. Auxiliary Control Devices
14. Wiring and Raceways
15. Smoke Detection for Projects with a Building Fire Alarm System

B. This is a performance specification and Contractor is responsible for design tasks and engineering.

1.2 RELATED SECTIONS

A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, meet the following:
1. Current edition of ANSI/ASHRAE Standard 135 and addendum, BACnet.
2. Current edition of UL 916 Underwriters Laboratories Standard for Energy Management Equipment, Canada and the US.
3. Current edition of FCC Part 15, Subpart J, Class A.
4. Current edition of BACnet Testing Laboratories (BTL).

1.4 SUBMITTALS

A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, provide:

1. Prepare and submit a detailed schedule of work. Schedule to identify milestones such as equipment submittals, control panel diagrams, color graphic panel displays, Interlock.
2. Wiring diagrams, control program sequence software flow chart diagrams, conduit layout diagrams, device location diagrams, equipment and component deliveries, installation sequencing, controller startup, point to point startup, control programming, sequence testing, commissioning/acceptance testing and training.
3. Submit design drawings, sequences of operation, program listings, software flow charts and details for each typical piece of equipment and system being controlled. No work to be initiated or fabrication of any equipment started prior to the Owner's Authorized Representatives return of REVIEWED submittals.
    a. Sequence of Operation: The sequence of operation included in the design documents is intended only to communicate the Engineers' general control intent and is not to be used as a direct reference for programming of the EMS system. Verbatim duplication of the Engineer's Sequence of Operation on the submittals is discouraged and may result in non-approval of the submittal. Sequence of operation on submittals to accurately detail the system's intended programming, and include details of enhancements, adjustments, or deviations from the Engineer's sequence of operation. Submitted sequence of operation to be written with a logical and organized format and flow. Provide detailed, clear and unambiguous sequence of operation language. Point descriptors and point nomenclature referenced in the submitted sequence of operation to match those (to be) actually programmed. As-built submittal Sequence of Operation to include modifications to the programming made as a result of any addendum, bulletins, RFI's, change orders, and commissioning.
4. Format: Make each submittal in one complete and contiguous package. Partial or unmarked submittals will be rejected without review.
5. Submit Manufacturers Data as Follows:
    a. Complete materials list of items proposed to be furnished and installed. A complete Bill of Materials, listing materials, components, devices, wire and equipment are required for this work. The Bill of Materials to be separate for each controller on its own page(s) and to contain the following information for each item listed:
        1) Manufacturer's Name and Model number with furnished options highlighted.
        2) Quantity of each by controller location.
        3) Description of product (generic).
        4) Specified item.
        5) Operating range or span.
        6) Operating point or setpoint.
    b. Manufacturer's specifications and other data required demonstrating compliance with the specified requirements, including but not limited to: Catalog cuts, technical data and descriptive literature on hardware, software, and system components to be furnished.
    c. The data to be clearly marked and noted to identify specific ranges, model numbers, sizes, and other pertinent data. Submit printed manufacturer's technical product data for each control device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials and including printed installation instructions and start-up instructions.
    d. Unless specifically called for otherwise, provide bound copies of catalog cuts for standard products, not requiring specifically prepared Shop Drawings, for the following:
        1) Wire and Cable, Class II
        2) Face Plates for Devices
        3) Disconnect Switches for Power Control
    e. Where more than one item, size, rating or other variations appear on a catalog cut sheet, clearly identify items to be provided. These items to be properly indexed and referenced to identification numbers, designations and/or details on the Drawings.

6. Shop Drawings: Submit shop drawings for each controlled system, depicting the following information:
    a. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves and other control/monitoring devices.
    b. Label each control device with initial setting or adjustable range of control. Label points in schematic diagrams with termination at corresponding controller.
    c. Electrical Wiring: Clearly differentiate between portions of wiring that are factory installed and portions of be field-installed.
    d. Details of control panel faces, including controls, instruments, and labeling.
    e. Interfaces to equipment furnished under other Specification Sections identifying numbers of wires, termination location, voltages and pertinent details. Responsibility for each end of the interfaces to be noted on these drawings whether or not they are a part of this Section.
    f. System architecture diagram showing the global connectivity of new controllers and any existing systems that will be connected to.
7. Equipment locations, wiring and piping schematics, details, panel configurations, sizes, damper motor mounting details, valve schedules, and a points list keyed to specific hardware submittals. Control wiring depicted as fully annotated ladder diagrams with terminations identified, completely configured as to the exact panel, wiring, relay, switch, and component configuration.
8. Tag Number Lists: Develop instruments tag number system and submit list for approval. Coordinate methods and number block with the Owner's Authorized Representative.
9. Format the Shop and Field Drawings to Include:
    a. A Title Sheet containing a drawing list, abbreviations list, symbols list, site and vicinity maps for project location and schedules.
    b. Floor Plans showing proposed device locations and device nomenclatures.
    c. A Riser Diagram illustrating conduit relationships between devices shown on the Floor Plans. Show device nomenclatures.
    d. A Single-Line Diagram for each system showing signal relationships of devices within the system. Show device nomenclatures.
    e. A Wiring Diagram for each assembly, enclosure or free standing device, showing:
        1) The Devices Within
        2) Wiring Connections
        3) Wire Identification
        4) Voltage Levels
        5) Fuse Ratings
    f. Operations and Maintenance Manuals:
        1) Following approval of Shop Drawings of control equipment and prior to acceptance of control work, prepare Operating and Maintenance manuals describing operating, servicing, and maintenance requirements of control systems and equipment installed under this Section, in accordance the General and Special Conditions of these Specifications.
        2) Information contained in the manual for the above equipment to include the following:
            (a) Manufacturer's catalog cuts and printed descriptive bulletins.
            (b) Manufacturer's installation, operating, and maintenance instruction booklets. Complete instructions regarding the operation and maintenance of equipment involved.
            (c) Instrument calibration certificates.
            (d) Parts list and costs.
            (e) Complete nomenclature of replaceable parts, list of recommended spare parts for 12 months operation, their part numbers, current cost and name and address of the nearest vendor of replacement parts.
            (f) Name, address and telephone number for closest source of spare parts.

(g) Wiring and schematic diagrams.
(h) Include final record copies of shop drawings.
(i) Copy of guarantees and warranties issued for the various items of equipment, showing dates of expiration.
(j) Reduced plans, diagrams, and control schematics.
(k) Copies of test results.
(l) Control System Operating Manual including: point of summary and point data base; complete printout of program listings; magnetic tape CD or DVD backup of Field Control Cabinet programs; cabinet layout; hard copy of graphic screens; hard copy of specified reports.

g. A final Bill of Quantities including a separate schedule for portable equipment, if delivered as part of this work.
h. Performance, Test and Adjustment Data: Comprehensive documentation of performance verification according to parameters specified in these specifications.
i. Record Drawings: Comply with Division 01, General Requirements and Section 23 00 00, HVAC Basic Requirements. Provide complete as-built submittals including "as-programmed" sequence of operation as well as final occupancy schedules.

1.5 QUALITY ASSURANCE

A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, meet the following:
1. Installer Qualifications: Company specializing in performing work of the type specified in this Section with minimum five years' experience in the local area. Installers required to have successfully completed manufacturer's control system factory training.

1.6 WARRANTY

A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.7 SYSTEM DESCRIPTION

A. Control system referenced throughout specifications and drawings as Building Automation System (BAS), Building Management System (BMS), or Energy Management System (EMS) interchangeably consists of high-speed, peer-to-peer network of DDC controllers, control system server, and operator workstation.

B. System software based on server/thin-client architecture, designed around open standards of web technology. Control system server accessed using a web browser over control system network, Owner's local area network, and remotely over Internet (through Owner's LAN). Intent of thin-client architecture is to provide operators complete access to control system via web browser. No special software other than web browser required to access graphics, point displays, and trends.

C. Local Area Network (LAN) either 10 or 100 Mpbs Ethernet network.

D. System will consist of open architecture that is capable of:
1. High speed Ethernet communication using TCP/IP protocol.
2. Native BACnet communications according to ANSI / ASHRAE Standard 135, latest edition. Provide necessary BACnet-compliant hardware and software to meet the system's

functional specifications. Controller devices must be BTL tested and listed by an official BACnet Testing Laboratory and have the BTL mark issued.

E. Complete temperature control system to be DDC with electronic sensors and electronic/electric actuation valves and dampers.

F. Prepare individual hardware layouts, interconnection drawings, building riser/architecture diagram and sequence of control from the project design data. Any architecture diagrams on design drawings have been included as schematics only and are not meant to portray quantity of devices or power/data requirements.

G. Design, provide, and install equipment cabinets, panels, data communication network infrastructure (including cables, conduits, outlets, connections, etc.) needed, and associated hardware.

H. Provide complete manufacturer's specifications for items that are supplied. Include vendor name and model number of every item supplied.

I. Provide a comprehensive operator and technician training program as described in these Specifications.

J. Provide as-built documentation, operator's terminal software, diagrams, and other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.

K. Provide 120V power, low voltage power, transformers, etc. for control panels, transformer panels, and BAS devices. Install per Division 26, Electrical Specifications. Power for devices within this Specification Section is solely the responsibility of the BAS Contractor.

L. Conduit and raceway systems. Provide per Division 26, Electrical Specifications.

M. Devices, components, controllers, and software to be manufacturer's most current version at the time of installation.

1.8 SYSTEM PERFORMANCE

A. Performance Standards - System conforms to following minimum standards over network connections:
   1. Graphic Display: Graphic with 20 dynamic points display with current data within 10 seconds.
   2. Graphic Refresh: Graphic with 20 dynamic points update with current data within 8 seconds.
   3. Object Command: Devices react to command of binary object within 2 seconds. Devices begin reacting to command of analog object within 2 seconds.
   4. Object Scan: Data used or displayed at controller or workstation have been current within previous 6 seconds.
   5. Alarm Response Time: Object that goes into alarm is annunciated at workstation within 45 seconds.
   6. Program Execution Frequency: Custom and standard applications are capable of running as often as once every 5 seconds. Select execution times consistent with mechanical process under control.
   7. Performance: Programmable controllers are able to completely execute DDC PID control loops at frequency adjustable down to once per second. Select execution times consistent with mechanical process under control.

8. Multiple Alarm Annunciation: Each workstation on network receive alarms within 5 seconds of other workstations.

B. Reporting Accuracy: System reports values with minimum end-to-end accuracy listed in Reporting Accuracy Table below.
   1. Reporting Accuracy Table:

Measure Variable	Reported Accuracy
Space Temperature	Plus or Minus 1 degree F
Ducted Air	Plus or Minus 1 degrees F
Outside Air	Plus or Minus 2 degrees F
Dew Point	Plus or Minus 3 degrees F
Water Temperature	Plus or Minus 1 degree F
Delta-T	Plus or Minus 0.25 degree F
Relative Humidity	Plus or Minus 5 percent RH
Water Flow	Plus or Minus 2 percent of full scale

   2. Note 1: Accuracy applies to 10 percent-100 percent of scale
   3. Note 2: For both absolute and differential pressure
   4. Note 3: Not including utility-supplied meters

C. Control Stability and Accuracy. Control loops maintain measured variable at setpoint within tolerances listed in Control Stability and Accuracy Table below.
   1. Control Stability and Accuracy Table:

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	Plus or minus 0.2 inch wg	0-6 inch wg
Airflow	Plus or minus 10 percent of full scale	
Space Temperature	Plus or minus 2.00 degrees F	
Duct Temperature	Plus or minus 3.0 degrees F	
Humidity	Plus or minus 5 percent RH	
Fluid Pressure	Plus or minus 1.5 PSI	1-150 PSI
	Plus or minus 1.0 inch wg	0-50 inch wg differential

PART 2 - PRODUCTS

2.1 NORTHERN CALIFORNIA MANUFACTURERS/INSTALLERS

A. Alerton/Syserco Inc

B. Automated Logic/Sunbelt Controls, Air Systems Inc

C. Andover (Schneider Electric)/Steven Engineering, Alameda Electrical Distributors Inc, Graybar Electric Company Inc, Powermatic Associates

D. Duct/Spot-Type Smoke Detectors (Project with Fire Alarm System):
   1. See Division 28 for Products.

2.2 COMMUNICATIONS

A. Each controller to have communication port for connection to operator interface.
   1. Internetwork operator interface and value passing to be transparent to internetwork architecture.
   2. Operator interface connected to controller to allow operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, reports, system software, and custom programs to be viewable and editable from each internetwork controller.

B. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers to be readable by each controller on internetwork.

C. Operator Workstation to be capable of simultaneous direct connection and communication with BACnet/IP, OPC and TCP/IP networks without use of interposing devices such as PC or gateway with hard drive.

D. Workstations, Building Control Panels and Controllers with real-time clocks use time synchronization service. System automatically synchronizes system clocks daily from operator-designated device via internetwork. System automatically adjusts for daylight savings and standard time as applicable.

2.3 OPERATOR INTERFACE

A. Operator Interface: PC-based workstations reside on high-speed network with building controllers. Each workstation or each standard browser connected to server is able to access system information.

B. Hardware: Each operator workstation or web server consists of the following:
   1. Computer: Hardware meets or exceeds DDC system manufacturer's recommended specifications and meet response times specified elsewhere in this document. Following hardware requirements also apply:
      a. Hard disk have sufficient memory to store:
         1) Required operator workstation software.
         2) One year of trend data based on points specified to be trended at specified trend intervals.
      b. Minimum hardware configuration includes:
         1) Intel i7 Processor
         2) 22-in LCD Monitor with at least 1024 x 768 Resolution
         3) 8 GB of RAM
         4) 48x CD-RW/DVD Optical Drive
         5) 1 TB Hard Disk Drive Providing Data at 3 GB/sec
         6) Ethernet 10/100 Network Interface Card
         7) High Performance Graphics Card
         8) Keyboard and Mouse
         9) Color Inkjet Printer
         10) UPS (uninterruptible power supply) installed at server, sized with sufficient capacity to allow full operation for 10 minutes or more.
   2. Portable Operator's Terminal: Portable Operator's Terminal capable of accessing system data. This device may be connected to any point on system network or to any controller for programming, setup, and troubleshooting. Portable Operator's Terminal is IBM-compatible notebook-style PC including software and hardware required. PC contains at minimum:
      a. Intel i5 Processor

b. 15-in LCD Monitor with at least 1024 x 768 Resolution
c. 8 GB of RAM
d. 1 TB Hard Drive
e. Touch-Pad or Other Internal Pointing Device
f. High-Performance Graphics Adapter
g. Ethernet 10/100 Network Interface Card
h. Integrated Wireless 802.11 b/g/n
i. Serial Port and CD/RW-ROM
j. Internal Modem, 56Kb Minimum

C. System Software:
1. Operating System: Furnish concurrent multi-tasking operating system. Operating system also supports use of and includes other common software applications such as Microsoft Excel, Word, Microsoft Access and Adobe Acrobat. Acceptable operating systems are Windows 7 and Windows 10.
2. Dynamic Color Graphics:
a. Real-time color graphic displays dynamic and able to update displays.
b. Provide operator ability to change values (setpoints) and states in system controlled equipment directly from graphic display.
c. Custom Graphics. Provide custom graphics generation package.
d. Graphics Library. Furnish library of standard HVAC equipment graphics and include standard symbols for fans, pumps, coils, valves, piping, dampers, and ductwork.
3. Software to be manufacturer's most current version at the time of installation.

D. System Applications: Each workstation provides operator interface and off-line storage of system information. Provide following applications at each workstation:
1. Automatic System Database Save and Restore: Each workstation stores on hard disk copy of current database of each Building Controller. This database automatically updated whenever change is made in any system panel.
2. Manual Database Save and Restore: System operator able to manually save or clear database and initiate download of specified database from/to any panel.
3. System Configuration: Workstation software provides method of configuring system to allow for changes or additions by users and performs following tasks:
a. Create, delete or modify control strategies.
b. Add/delete objects to system.
c. Tune control loops through adjustment of control loop parameters.
d. Enable or disable control strategies.
e. Generate hard copy records of control strategies on printer.
f. Select points to be alarmed and define alarm state.
g. Select points to be trended and initiate automatic recording of values.
h. Start/Stop binary objects and adjust analog objects.
4. Security: Operator required to log on to system with user name and password in order to view, edit, add, or delete data. System security selectable for each operator.
5. System Diagnostics: System automatically monitor operation of workstations, printers, modems, network connections, building management panels, and controllers. Failure of any device to be annunciated.
6. Alarm Indication and Handling:
a. Workstation provides visual means of alarm indication. Alarm indication becomes highest priority regardless of application(s) running.
b. System provides and archive log of alarm messages to hard drive. Alarm messages to include description of event-initiating object, source, location and time/date of alarm.
7. Trend Logs: Operator able to define custom trend log for any data object and include interval, start time, and stop time. Trend data sampled and stored on building controller

panel, is archived on hard disk, and is retrievable for use in spreadsheets and standard database programs.

a. System server to periodically gather historically recorded data stored in the building controllers and archive the information. Archived files to be appended with new sample data, allowing samples to be accumulated.
b. Software to be included that is capable of graphing the trend logged object data. Software capable of creating two-axis (x,y) graphs that display object values relative to time.
c. Operator able to change trend log setup information. This includes the information to be logged as well as the interval at which it is to be logged. Input, output, and value object types in the system may be logged. Provide operations password protected. Setup and viewing may be accessed directly from any graphics on which object is displayed.
d. BAS Contractor to enable trending for any system points (physical or virtual) as directed by the Engineer, Owner or Commissioning Authority (Commissioning Authority). There will be no limit on the number of trended points the BAS Contractor is to set up. BAS Contractor will modify trend setup parameters as directed by the Commissioning Authority during testing. BAS Contractor to be proactive and enable trending for major system points during system startup/programming. BAS Contractor is not to wait for direction to begin trending points. Trend data for each point to be archived on the main server for a minimum of one year. Trend data archiving to be enabled immediately upon trend setup, or as soon as communication between the field panel and sever is established. Trend data uploads from field panel to server set up to be automatically performed with sufficient frequency to ensure no data gaps or loss of trend data.
e. Trend points as identified in the points list. Provide system specific trend data in two-axis (x,y) graphs that display object values relative to time to Engineer, Owner, or Commissioning Authority.

8. Standard Reports: Standard system reports provided for this project. Provide ability for Owner to readily customize these reports for this project:
   a. Objects: System (or subsystem) objects and their current values.
   b. Logs:
      1) Alarm History
      2) System Messages
      3) System Events
      4) Trends
9. Electrical, Gas, and Weather Report:
   a. System server capable of periodically gathering energy log data stored in the field equipment and archive the information. Archive files appended with new data, allowing data to be accumulated.
   b. Operator able to change the energy log setup information as well. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. Meters monitored by the system may be logged.
   c. System to display archived data in tabular format form for both consumption and peak values. Data shown in hourly, daily, weekly, monthly and yearly formats. In each format the user able to select a specific period of data to view.
   d. Electrical Meter Report: Provide monthly report showing daily electrical consumption and peak electrical demand with time and date stamp for each building meter and for each electrical sub-meter on individual building panels, circuits, equipment (such as chillers), and variable frequency drives. Provide an annual (12-month) report showing monthly electrical consumption and peak electrical demand with time and date stamp for each individual meter.
   e. Weather Data Report: Provide monthly report showing daily minimum, maximum, and average outdoor air temperature (dry bulb, wet bulb) and humidity. Provide annual

(12-month) report showing minimum, maximum, and average outdoor air temperature for month.

E. Interfaces to Third Party Systems: BAS connects to third party systems (VFDs, chillers, emergency generators, rooftop AC units, etc.). Communication protocol specified for third party system, and BAS provides compatible protocol to assure proper two way communication. Points, alarms, and commands displayed on BAS as indicated.

F. Workstation Applications Editors: Each PC workstation supports editing of system applications, which downloaded and executed at one or more controller panels.

2.4 CONTROLLER SOFTWARE

A. Furnish following applications software for building and energy management. Software applications reside and operate in system controllers. Software to be manufacturer's most current version at the time of installation. Software and associated functions (scheduling, optimum start/stop, etc.) noted in this specification are to be configured and enabled for this project. Incorporate into sequence of operation submittals for review prior to installation.

B. System Security:
1. User access secured using individual security passwords and user names.
2. Restrict user passwords to objects, applications, and system functions as assigned by system manager. Provide monitoring only access to Engineer of Record and Commissioning Authority for period of one year for trouble shooting purposes.
3. Record user Log On/Log Off attempts.
4. Provide passwords, user names, and access assignments adjustable at the operator's terminal. Each user to have a set security level, which defines access to displays and individual objects the user may control. System to include 10 separate and distinct security levels for assignment to users.
5. System to include an Auto Logout Feature that will automatically logout user when there has been no keyboard or mouse activity for a set period of time. Time period to be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal to display message on screen that user is logged out after Auto Logout occurs.

C. Scheduling: Provide capability to schedule each object or group of objects in system. Coordinate schedule with Owner and program accordingly. Each schedule consists of:
1. Operator's workstation to show information in easy-to-read daily format. Priority for scheduling: Events, holidays and daily with events being the highest.
2. Holiday and special event schedules to display data in calendar format. Operator able to schedule holidays and special events directly from these calendars.
3. Operator able to change information for a given weekly or exception schedule if logged on with the appropriate security access.

D. Optimum Start/Stop: Provide software and program system to start equipment on sliding schedule based upon indoor and outdoor conditions. Determine minimum time of HVAC system operation needed to satisfy space environmental requirements and also determine earliest possible time to stop mechanical systems (i.e. shut down cooling/heating and only provide ventilation one hour prior to scheduled unoccupied period.) Optimum start/stop program operates in conjunction with scheduled start/stop and night setback programs.

E. Alarms:
1. Operator's workstation to provide visual means of alarm indication. The alarm dialog box to always become the top dialog box regardless of the application(s), currently running.

2. System to provide log of alarm messages. Alarm log to be archived to the hard disk of the system operator's terminal. Each entry to include a description of the event-initiating object generating the alarm. Entry to include time and date of alarm occurrence.
3. Alarm messages in user-definable text and entered either at the operator's terminal or via remote communication.
4. Each binary object set to alarm based on operator-specified state.
5. Each analog object have both high and low alarm limits.
6. Alarms must be able to be automatically and manually disabled.
7. Alarms are routed to appropriate workstations based on time and other conditions. An alarm is able to start programs, print, be logged in event log, generate custom messages, and display graphics.
8. System have ability to dial out in event of alarm.
9. Alarm Levels:
    a. Provide 5 levels of alarm as follows, and program alarm levels for every required and specified alarm:
        1) Level 1: Critical/life safety.
        2) Level 2: Significant equipment failure.
        3) Level 3: Non-critical equipment failure/operation.
        4) Level 4: Energy conservation monitor.
        5) Level 5: Maintenance indication, notification.
    b. Prior to training of Owner’s Authorized Representative, submit the complete Points List and suggested Alarm Levels to the Owner.
    c. During training of Owner’s Authorized Representative(s):
        1) Discuss Alarm Levels and the alarms currently included in the BAS.
        2) Provide additional alarms without addition of new hardware points, as required by Owner’s Authorized Representative.
        3) Agree with the Owner’s Authorized Representative on action(s) to be taken for each alarm level and implement same for each alarm. Said action to include visual and/or audible alarm(s) at the Operator workstation including whether Operator acknowledgement is required or not, email messages, and text messages.

F. Demand Limiting:
1. System to include demand limiting program that includes two types of load shedding. One type of load shedding to shed/restore equipment in binary fashion based on energy usage when compared to shed and restore settings. The other type of shedding to adjust operator selected control setpoints in an analog fashion based on energy usage when compared to shed and restore settings. Shedding may be implemented independently on each and every zone or piece of equipment connected to system.
2. Status of each and every load shed program capable of being displayed on every operator terminal connected to system. Status of each load assigned to an individual shed program displayed along with the description of each load.
3. Demand-limiting program monitor building power consumption from signals generated by pulse generator (provided by BAS contractor) mounted at building power meter or from watt transducer or current transformer attached to building feeder lines.
4. Demand-limiting program predicts probable power demand so that when demand exceeds demand limit, action will be taken to reduce loads in predetermined manner. When demand limit will not be exceeded, action will be taken to restore loads in predetermined manner.

G. Maintenance Management: System monitors equipment status and generate maintenance messages based upon user-designated run-time, starts, and/or calendar date limits. Coordinate settings with Owner.

H. Sequencing: Provide application software based upon sequences of operation specified to properly sequence designated systems. Provide points to achieve specified sequences.

I. Staggered Start: This application prevents controlled equipment from simultaneously restarting after a power outage. Order in which equipment (or groups of equipment) is started, along with time delay between starts to be user-selectable.

J. Energy Calculations: Provide software to allow instantaneous power (e.g. kW) or flow rates (e.g. L/s (gpm)) to be accumulated and converted to energy usage data.

K. Anti-Short Cycling: Binary output objects protected from short cycling by allowing minimum on-time and off-time to be selected.

L. On/Off Control with Differential: Provide algorithm that allows binary output to be cycled based on controlled variable and setpoint. Algorithm direct-acting or reverse-acting and incorporate adjustable differential.

M. Run-Time Totalization: Provide software to totalize run-times for binary input objects.

2.5 WEB BASED ACCESS

A. General Description: BAS supplier to provide web-based access to the system as part of standard installation. Provide access to user of displays of real-time data that are part of the BAS via a standard Web browser. Web browser to tie into the network via Ethernet network connection. Provide web-page host that resides on the BAS network. Web-page software not to require a per user licensing fee or annual fees. The web-page host must be able to support at least 50 simultaneous users with the ability to expand the system to accommodate an unlimited number of users. Software to be manufacturer's most current version at time of installation.

B. Browser Technology: Browser to be standard version of Microsoft Internet Explorer (latest edition). No special vendor-supplied software needed on computers running browser. Displays viewable and the Web-page host to directly access real-time data from the BAS network. Data displayed in real time and update automatically without user interaction. User able to change data on displays if logged in with the appropriate user name and password.

C. Display of Data: Web page graphics shown on browser to be replicas of the BAS displays. User to need no additional training to understand information presented on Web pages when compared to what is shown on BAS displays. Web page displays to include animation just as BAS displays. Fans to turn, pilot lights to blink, and coils to change colors, and so on. Real-time data shown on browser Web pages. This data must be directly gathered via the BACnet network and automatically updated on browser Web page displays without any user action. Data on the browser to automatically refresh as changes are detected without re-drawing the complete display. User to be able to change data from browser Web page to if the user is logged on with the appropriate password. Clicking on a button or typing in a new value to change digital data. Using pull-down menus or typing in a new value to change analog data. Data displays navigated using pushbuttons on the displays that are simply clicked on with the mouse to select a new display. Alternatively, the standard back and forward buttons of the browser can be used for display navigation.

D. Web Page Generation: Web pages generated automatically from the BAS displays that reside on the BAS server. User to access Web-page host via the network and initiate a web page generation utility that automatically takes the BAS displays and turns them into Web pages. The Web pages generated are automatically installed on the Web page host for access via any

computer's standard browser. Any system that requires use of an HTML editor for generation of Web pages will not be considered.

E. Password Security and Activity Log: Access via Web browser to utilize the same hierarchical security scheme as BAS system. User asked to log in once the browser makes connection to Web-page host. Once the user logs in, any changes that are made to be tracked by the BAS system. User able to change only those items that the user has authority to change. A user activity report to show any activity of the users that have logged in to the system regardless of whether those changes were made using a browser or via the BAS workstation.

F. Communication: Web-page host to communicate using the specified protocol standard to devices on the BAS network.

2.6 BAS GRAPHICS

A. Develop customized graphics showing the project building(s) and their floor plans, mechanical, and electrical equipment, flow and control diagrams, and other relevant features on Workstation graphic screens. Associated input, output, and virtual objects (e.g., temperature and pressure setpoints) listed in the Sequence of Operation, and shown on the Input/Output Objects List included in the graphic screens and bound to the database. Real-time value of objects updated on the display of each graphic automatically. For projects where existing campus and/or building controls systems exist, replicate graphics used in the existing BAS graphics screens.

B. Graphics to have links to the Print function and to display a Standard Legend in the corner of the graphic. Graphics, except pop-ups, to have the date and time displayed in the upper corner of the graphic. Each graphic titled.

C. Weather: Graphics, except pop-ups, to have the outdoor temperature and humidity in the upper corner of the graphic.

D. Alarms: System and component summary alarms located near the top of each relevant graphic screen. Provide links to the associated system/component as part of these tags to assist trouble shooting. Other alarms placed near the associated system/device as depicted in the graphic. Provide text and color of information tags that describe each object and alarm value consistent with a graphics color legend.

E. The Following Graphics Provided as a Minimum:
   1. A building graphic, typically a photograph of the building, with links to each floor plan and other links as defined below.
   2. A central plant graphic with equipment heat pump, pumps, heat exchangers, storage tanks, etc.), temperature sensors, pressure sensors, and flow sensors. The central plant graphic to have links to each building on the campus.
   3. Central equipment such as air handler, supply fans, and exhaust fans.
   4. Floor plans of each floor, with temperature sensors, pressure sensors, temperature control zones, heating/cooling zones, ventilation zones, and supply air zones identified. Rooms grouped on a graphic only to the extent that detailed and complete sensing information can be comfortably viewed by an operator and the bound points updated in less than 10 seconds. Each zone to have a temperature symbol that changes color over the range from low (blue) through normal (green) to high (red) and indicate an alarm (flashing red). The zone temperature and or pressure symbol(s) to be a link to a zone control pop-up graphic. Individual floor plan graphics to provide links to related mechanical systems. The mechanical room plan graphics to show the relative location of, and provide links to, either the equipment pop-up or flow and control graphic for mechanical equipment monitored or controlled by the BAS.

5. Pop-up graphics provided for each zone control system showing a flow diagram and related monitoring and control points and system parameters. Pop-up graphics provided for each piece of equipment that is not shown on a flow and control graphic.
6. Flow and control diagrams for each system including but not limited to central plant, fan coils, generators, packaged equipment, chilled water systems, heating hot water systems, heat exchangers, pumps, storage tanks, zone terminal units, combination fire and smoke damper status, and ventilation systems. The flow and control graphics to have parameters grouped in the lower portion of the graphics. Standard equipment graphics used. Pumps, fans, dampers and other elements to dynamically indicate their state (i.e. pumps and fans to rotate when on and damper positions to dynamically adjust and be shown in their current position, etc.). System flow and control graphics displayed in a general left to right flow or loop arrangement. Return and exhaust air flow shown on top and return water shown on the bottom of the graphic.
7. Individual equipment/component screens showing sensing and control information available for each device provided.

F. Penetration: The graphic interface to consistently apply a convention whereby a left-click to always penetrate to more detailed information. The text windows to represent the deepest level of penetration. A right-click to always produce a menu of options that are specific to the item selected.

G. Navigation: Graphics organized to provide a "branching structure" that allows an operator to move from a "macro view" to a "micro view" and return. These links to other associated graphics, or allow a return to a previous macro view, provided and arranged horizontally along the bottom of each graphic screen. From left to right, the graphic links as follows: site/building map, building/trailer floor plans, and major mechanical systems at each building. Pop-up right click menus provided as needed on the lower button bar to allow for uncluttered navigation.

H. Clutter Minimization: Each graphic to have separate check boxes in the lower right corner that show/hide setpoints, alarms/safeties, and devices/equipment.

I. Templates: To the maximum extent possible, use standard graphics as templates to provide a consistent look throughout the interface.

J. Color Scheme: The graphics to use dynamic color changes to communicate equipment type, or object status consistent with the graphics color legend.

K. Symbols and Animations: Fans, pumps, dampers, coils, and generation equipment to be dynamic symbols indicating rotation, state, or position, movement, flow, etc.

L. Macros: When macros are used to add functionality to the graphics, detailed documentation provided.

M. Configure Mode: Access to “Configure Mode” for editing of the graphics password protected to prevent unauthorized changes to the graphics. This password supplied to the appropriate personnel.

N. Graphics Version: Graphics provided in the most current format available at time of control system programming.

O. Points and graphics checked for the proper binding and graphic programming, settings to ensure that the correct system, location, point values and dynamics are shown in the proper location and rotate in the proper directions.

P. After graphics have been accepted, provide, on a CD ROM in an agreed upon file structure. If the graphics have active-x controls or other files that must be placed outside the graphics folder structure a set-up program provided on the disk to place the files in the correct locations.

2.7 BUILDING CONTROLLERS

A. General: Provide adequate number of building controllers to achieve performance specified. Panels to meet the following requirements.
   1. Building Automation System (BAS) to be composed of one or more independent, stand-alone, microprocessor-based building controllers to manage global strategies described in Controller Software article.
   2. Provide sufficient memory to support operating system, database, and programming requirements.
   3. Share data between networked building controllers.
   4. Distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
   5. Controllers that perform scheduling have real-time clock.
   6. Continually check status of its processor and memory circuits and if abnormal operation is detected, controller:
      a. Assume predetermined failure mode.
      b. Generate alarm notification.
   7. Building Controller communicates with other devices on internetwork including BACnet communications according to specified protocol.

B. Communication:
   1. Each building controller resides on network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and performs routing to network of custom application and application specific controllers.
   2. Controller provides a service communication port for connection to a portable operator's terminal.

C. Environment:
   1. Controllers used outdoors and/or in wet ambient conditions mounted within NEMA waterproof enclosures and rated for operation at 0 degrees F to 150 degrees F.
   2. Controllers used in conditioned space are mounted in NEMA dust-proof enclosures and rated for operation at 32 degrees F to 120 degrees F.

D. Serviceability: Provide diagnostic LEDs for power, communication, and processor. Wiring connections are made to modular terminal strips or to termination card connected by ribbon cable.

E. Memory: Building controller maintains BIOS and programming information in event of power loss for at least 72 hours.

F. Immunity to power and noise. Controller able to operate at 90 percent to 110 percent of nominal voltage rating and performs an orderly shutdown below 80 percent nominal voltage. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3-feet.

G. Controller to have a battery to provide power for orderly shutdown of controller and storage of data in nonvolatile flash memory. Battery backup to maintain real-time clock functions for a minimum of 10 days.

2.8 APPLICATION SPECIFIC CONTROLLERS

A. Application specific controllers (ASCs) are microprocessor-based DDC controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers to be fully programmable using graphical programming blocks.
   1. ASC controllers communicate with other devices on internetwork.
   2. Each ASC capable of stand-alone operation without being connected to network.
   3. Each ASC will contain sufficient I/O capacity to control target system.
   4. Application controllers to include universal inputs with minimum 10-bit resolution that accept thermistors, 0-10VDC, 0-5 VDC, 4-20 mA and dry contact signals. Any input on a controller may be either analog or digital with at least 1 input that accepts pulses. Controller to also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller to include binary and analog outputs on board. Provide analog outputs switch selectable as either 0-10VDC or 0-20mA. Software to include scaling features for analog outputs. Application controller to include 24VDC voltage supply for use as power supply to external sensors.
   5. Program sequences stored on board application controller in EEPROM. No batteries needed to retain logic program. Program sequences executed by controller 10 times per second and capable of multiple PI and PID loops for control of multiple devices. Calculations completed using floating-point math and system to support display of information in floating-point nomenclature at operator's terminal. Programming of application controller completely modifiable in the field over installed BAS LANs or remotely via modem interface. Operator to program logic sequences by graphically moving function blocks on screen and tying blocks together on screen.
   6. Application controller to include support for room sensor. Display on room sensor programmable at application controller and include an operating mode and a field service mode. Provide button functions and display data programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

B. Communication:
   1. Controller resides on network using MS/TP Data Link/Physical layer protocol.
   2. Each controller connected to building controller.
   3. Each controller capable of connection to laptop computer or portable operator's tool.

C. Environment:
   1. Controllers used outdoors and/or in wet ambient conditions mounted within NEMA waterproof enclosures and rated for operation at 0 degrees F to 150 degrees F.
   2. Controllers used in conditioned space mounted in NEMA dust-proof enclosures and rated for operation at 32 degrees F to 120 degrees F.

D. Serviceability: Provide diagnostic LEDs for power, communication, and processor.

E. Memory: ASC use nonvolatile memory and maintains BIOS and programming information in event of power loss.

2.9 ADVANCED APPLICATION CONTROLLERS

A. General:
   1. Expandable application controller capable of providing control strategies for the system based on information from any connected inputs. Provide program implementing these strategies completely flexible and user definable. Provide program execution of controller a minimum of once per second.

2. Programming: Object-oriented using control program blocks. Controller to support a minimum of 500 Analog Values and 500 Binary Values. Each and every analog and binary value to support standard specified protocol priority arrays.
3. Provide means to graphically view inputs and outputs to each program block in real-time as program is executing. This function may be performed via the operator's terminal or field computer.
4. Controller to have adequate data storage to ensure high performance and data reliability. Battery to retain static RAM memory and real-time clock functions for a minimum of 1.5 years (cumulative). Provide field-replaceable battery (non-rechargeable) lithium type. Unused battery life: 10 years.
5. The onboard, battery-backed real time clock must support schedule operations and trend logs.
6. Global control algorithms and automated control functions should execute via 32-bit processor.
7. Controller to include both on-board Ethernet specified protocol communication over twisted pair cable (UTP) and to include specified protocol IP communication. In addition, controller to include specified protocol PTP connection port.
8. The base unit of the controller to host up to 8 expansion modules with various I/O combinations. These inputs and outputs to include universal 12-bit inputs, binary triac outputs, and 8-bit switch selectable analog outputs (0-10V or 0-20 mA). Inputs to support thermistors, 0-5VDC, 0-10VDC, 4-20mA, dry contacts and pulse inputs directly.
9. Outputs must have onboard Hand-Off-Auto switches and a status indicator light. HOA switch position to be monitored. Each analog output to include a potentiometer for manually adjusting the output when the HOA switch is in the Hand position.
10. The position of each and every HOA switch to be available system wide as a specified protocol object. Expandable Controller to provide up to 176 discreet inputs/outputs per base unit.

B. Schedules: Each controller to support a minimum of 50 Schedule Objects.

C. Logging Capabilities: Each controller to support a minimum of 200 trend logs. Any object in the system (real or calculated) may be logged. Sample time interval adjustable at the operator's workstation.

D. Alarm Generation:
1. Alarms may be generated within the system for any object change of value or state either real or calculated. This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
2. Alarm log provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site via remote communications.
3. Controller must be able to handle up to 200 alarm setups stored as event enrollment objects - system destination and actions individually configurable.

2.10 APPLICATION SPECIFIC CONTROLLER - TERMINAL UNIT CONTROLLERS

A. Provide one application controller for each terminal unit that adequately covers objects listed in object list for unit. Controllers to interface to building controller via LAN using specified protocol. Controllers to include on board flow sensor, inputs, outputs and programmable, self-contained logic program as needed for control of units.

B. Application controllers to include universal inputs with 10-bit resolution that can accept thermistors, 0-5 VDC, and dry contact signals. Inputs on controller may be either analog or digital. Controller to also include support and modifiable programming for interface to intelligent room sensor with digital display (digital display to indicate setpoint only). Controller to also

include binary outputs on board. For applications using variable speed parallel fans, provide a single analog output selectable for 0-10 V or 0-20 mA control signals. Application controller to include microprocessor driven flow sensor for use in pressure independent control logic. Terminal units controlled using pressure independent control algorithms and flow readings to be in CFM.

C. Program sequences stored on board application controller in EEPROM. No batteries needed to retain logic program. Program sequences executed by controller 10 times per second and capable of multiple PI loops for control of multiple devices. Provide programming of application controller completely modifiable in the field over installed specified protocol LANs or remotely via modem interface. Operator to program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller programmed using the same programming tool as Building Controller and as described in Operator Workstation article.

D. Application controller to include support for intelligent room sensor. Display on room sensor programmable at application controller and include an operating mode and a field service mode. Button functions and display data programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence for specific display requirements for intelligent room sensor.

E. Provide duct temperature sensor at discharge of each terminal unit that is connected to controller for reporting back to operator workstation. Provide analog inputs for the duct temperatures.

2.11 INPUT/OUTPUT INTERFACE

A. Input/output points protected such that shorting of point to itself, to another point, or to ground will cause no damage to controller. Input and output points protected from voltage up to 24 V.

B. Binary inputs (BI or DI) allow monitoring of On/Off signals from remote devices. Binary inputs sense “dry contact” closure without external power (other than that provided by controller) being applied.

C. Pulse accumulation input objects accept up to 10 pulses per second for pulse accumulation.

D. Analog inputs (AI) allow monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD).

E. Binary outputs (BO or DO) provide for On/Off operation or pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers have three-position (On/Off/Auto) override switches and status lights. Outputs selectable for either normally open or normally closed operation.

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

G. 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 limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted

heating coils, zone dampers, radiation, etc.). Control algorithms run zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.12 POWER SUPPLIES AND LINE FILTERING

A. Control transformers UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits. Limit connected loads to 80 percent of rated capacity.

B. DC power supply output match output current and voltage requirements. Unit operates between 32 degrees F and 120 degrees F.

C. Line voltage units UL listed and CSA approved.

D. Power line filtering. Provide transient voltage and surge suppression for workstations and controllers.

2.13 CONTROL PANELS

A. Control Panels:
1. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment. Indoor enclosures to be NEMA 12 when installed in other than a clean environment. Outdoor enclosures must be NEMA 3R. Provide (hinged door) key-lock latch and removable subpanels. Single key common to field panels and subpanels. In existing campus or building settings, key lock to match existing keys.
2. Interconnections between internal and face-mounted devices prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections UL listed for 600 volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection individually identified per control drawings.
3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.
4. Provide laminated plastic nameplates for enclosures in any mechanical room or electrical room labeled with TCP number. Laminated plastic to be 1/8-inch thick sized appropriately to make label easy to read.

2.14 AUXILIARY CONTROL DEVICES

A. Temperature Instruments:
1. Low-voltage or Line-voltage Thermostats: Bimetal-actuated, snap acting SPDT contact, enclosed, UL listed for electrical rating, exposed setpoint adjustment on cover with heat anticipator. Thermostat operates within 55 degrees F to 85 degrees F setpoint range, with 2 degrees F maximum differential.
2. Room Temperature Sensor: Thermistor or platinum RTD type with accuracy of plus or minus 0.5 degrees F at 70 degrees F; operating range 30-120 degrees F; linear signal; single point sensing element in wall-mounted ventilated enclosure with insulating back plate if mounted on exterior wall; push button for occupancy override; digital setpoint adjustment plus or minus 2 degrees F in both directions; LCD temperature display indicating setpoint only. Setpoint adjustment to revert to building programmed standard temperature upon next building occupancy schedule change (user adjustable). Room temperature sensor may have integral space carbon dioxide sensor with minimum performance characteristics identified within this specification.

3. Averaging Duct Temperature Sensors: Thermistor or platinum RTD element with accuracy of plus or minus 0.5 degrees F at 32 degrees F, consisting of array of single point sensing elements, securely mounted in duct or plenum; operating range 20-120 degrees F; linear signal; 1-foot element per 2 SF of duct cross-sectional area. Use when duct is 9 SF or larger or where air is subject to temperature stratification.
4. Probe Duct Temperature Sensors: Thermistor or platinum RTD element with accuracy of plus or minus 0.5 degrees F at 32 degrees F, consisting of single point sensing elements, securely mounted in duct or plenum; operating range 20-120 degrees F; linear signal; 24-inch rigid probe. Use where duct is less than 9 SF cross-sectional area.
5. Outside Air Temperature Sensor: Thermistor or platinum RTD element with accuracy of plus or minus 0.5 degrees F at 32 degrees F; Range -58 to 120 degrees F, single element, linear, with weather and sun shield for exterior mounting.
6. Low Temperature Limit Thermostat: Minimum 20 foot capillary sensing element, triggering on low temperature as sensed by any 12-inch segment; snap acting, normally open contacts, manual reset, line voltage.
7. Liquid Immersion Temperature Sensor: Thermistor or platinum RTD element, with accuracy of plus or minus 0.5 degrees F at 32 degrees F, stainless steel well and assembly, range 30 to 250 degrees F.

B. Humidity Sensors:
1. Space Humidity Sensors: Operating range 10 to 95 percent relative humidity, accuracy plus or minus percent RH, surface mounted ventilated enclosure for wall mounting.
2. Duct Humidity Transmitter: Capacitive type sensor and transmitter, linear output signal; automatic temperature compensating; air filter; plus or minus 2 percent RH accuracy from 0 to 100 percent RH.
3. Humidity sensor's drift not exceed 1 percent of full scale per year.

C. Dewpoint Transmitter:
1. Uninterrupted, accurate and stable dewpoint measurement in condensing environments. Provide with integral temperature sensor.
2. Calculate:
    a. Relative Humidity
    b. Absolute Humidity
    c. Difference between ambient and dewpoint temperature.
    d. Mixing Ratio of Air
    e. Wet Bulb Temperature of Air
3. Provide hand held field calibration.
4. Provide with local display and connection to BAS (analog output signal from device to BAS 4-20 mA signal).
5. Dust and Chemical Resistant
6. NEMA 4 Housing
7. NIST Traceable with Certificate
8. Specifications:
    a. Dewpoint Measurement Range:-40 degrees F to 212 degrees F
    b. Response Time: 15 seconds
    c. Temperature Measurement Range:40 degrees F to 356 degrees F
    d. Accuracy: 0.18 degrees F
    e. Typical Ranges:
        1) Relative Humidity: 0 to 100 percent
        2) Dewpoint Difference: 0 to 90 degrees F
        3) Mixing Ration: 0 to 3500 gr/lb
        4) Absolute Humidity: 0 to 262 gr/ft^3
        5) Wet Bulb Temperature: 32 degrees F to 212 degrees F
9. Manufacturers:

a. Vaisala HMP243 with HMK41 field calibrator.
b. Or approved Equivalent.

D. Pressure Transmitters and Transducers:
1. Transducer have linear output signal; field adjustable zero and span. Sensing elements withstand continuous operating conditions of positive or negative pressure 50 percent greater than calibrated span without damage.
2. Differential Pressure Switch: Setpoint adjustable with operating range of 0.5 to 12-inch WG for fans, and 5 to 30-feet WC for pumps. Switches UL listed; SPDT snap-acting; pilot duty rated (125 VA minimum); NEMA 1 enclosure; scale range and differential suitable for intended application.
3. Filter Differential Pressure Switch: Setpoint adjustable with operating range of 0.1 to 5-inch WG; auto reset. Contactor to close when pressure differential setting is met or exceeded. Provide mounting bracket, metallic tubing and appropriate fittings for connection to duct or air-handling unit.
4. Duct Static Differential Pressure Transducer: Operating range 0 to 5-inch WC for duct mounted transmitter; ceramic capacitive sensing element with probe securely mounted in duct; digital input terminal and push button to zero output. Accuracy plus or minus 1 percent of full scale; maximum response time 2 seconds.
5. Building Static Pressure Transducer: Operating range of -0.1 to 0.1-inch WC, linear signal. Sensing tubes located inside and outside building use shielding and/or surge tanks to minimize effects of wind. Accuracy plus or minus 1 percent of full scale.
6. Piping Pressure Transmitter: Operating range 0 to 50 PSIG, linear signal; stainless steel diaphragm; digital input terminal and push button to zero output. Accuracy plus or minus 1 percent of full scale.

E. Motorized Control Dampers:
1. Performance: Maximum leakage of 3 CFM/SF at 1-inch WG differential pressure, AMCA Class 1A, maximum pressure rating of 13-inch WG differential pressure, maximum velocity of 6,000 fpm, -72 degrees F to 275 degrees F temperature rating.
2. Multi-blade type, except where either dimension is less than 10-inch single blade may be used. Maximum blade length to be 48-inch.
3. Provide parallel blades for modulating mixing service and opposed blades for throttling service.
4. Blades to be interlocking; minimum 16 gauge galvanized steel; compression type edge seals and side seating stops. In copper, aluminum and stainless steel duct work, damper material matches duct work material.
5. Damper blades are reinforced, have continuous full length axle shafts, axle to axle linkage, and/or operating “jackshafts” as required to provide coordinated tracking of blades.
6. Bearings: Self-lubricating stainless steel sleeve or Celcon bearing.
7. Dampers over 25 SF in area to be in two or more sections, with interconnected blades.
8. Provide remote damper blade position status with binary input.
9. Tested in accordance with AMCA Standard No. 500.

F. Motorized Control Valves:
1. Body pressure rating and connection type construction conforms to pipe, fitting and valve schedules.
2. Fluid valve close-off ratings and spring ranges operate at maximum flows and maximum available pump heads scheduled without leakage.
3. Screwed ends except 2-1/2-inch and larger valves with flanged ends.
4. Steam valve close-off ratings operates at 150 percent of steam pressure without leakage.
5. Motorized Control Valves (Pressure Independent Control Valves):

a. Description: Valve consists of pressure compensating cartridge, actuated ball or Y pattern globe valve, and multiple pressure/temperature test ports in a single valve housing.
b. Construction: Rated for no less than 125 PSI and 250 degrees F. 2-inch and Smaller: brass with threaded connections. 2-1/2-inch and larger: cast iron with flanged connections.
c. Performance: Flow rate controlled linearly to within 5 percent of target flow rate, for any actuator position (0 to 100 percent), over an operating differential pressure range of 6 to 50 PSI across the valve. Provide valve with integral test ports to verify pressure differential.
d. Manufacturers: Belimo, Danfoss, Flow Control Industries, Griswold, Tour and Andersson or approved equivalent.

6. Fluid three-way valves globe valves with linear plug with composition disc for tight shutoff.
7. Pressure drop equal to twice pressure drop through heat exchanger (load), 50 percent of pressure difference between supply and return mains, or 5 PSI, whichever is greater, except two-position valves to be line size.
8. Bubble-tight line size butterfly valves acceptable on 2-1/2-inch lines and above for two-position action only; cast iron body; aluminum bronze disc; EPDM seat, 200 PSI wg
9. Steam Valves: Body and trim materials in accordance with manufacturer's recommendations for design conditions and service with linear ports for modulating service. Sizing Criteria:
   a. Two-Position Service: Pressure drop 10 percent to 20 percent of inlet PSIG.
   b. Modulating Service: 15 PSIG or less; pressure drop 80 percent of inlet PSIG.

G. Electric Damper/Valve Actuators:
1. Provide mechanical or electronic stall protection for each actuator.
2. Where indicated provide internal mechanical, spring-return mechanism or provide uninterruptible power supply (UPS). Non-spring-return actuators have external manual gear release to position damper/valve when actuator is not powered.
3. Proportional actuators accepts 0 to 10 VDC or 0 to 20 mA control signal and provide 2 to 10 VDC or 4 to 20 mA operating range.
4. Actuator sized for torque required plus 25 percent; UL or CSA listed; electronic current overload protection.
5. VAV Actuators: Actuators proportional 24 VAC actuators using a 4 to 20 mA range of control signals; stops automatically at end of travel; include permanently lubricated gear train.

H. Water Flow Meter:
1. Provide a Turbine Flow Meter (reference 23 05 19) complete with installation hardware necessary to enable insertion and removal of the meter without system shutdown. The flow meter hand-insertable up to 400 PSI. The flow meter to have two contra-rotating axial turbines, with electronic impedance-based sensing and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Wetted metal components nickel-plated brass. Provide 316L SS construction for hot water applications operating over 250 degrees F, and for any application in non-metallic pipe. The maximum operating temperature 280 degrees F, 300 degrees F peak. Each flow meter individually wet-calibrated against a primary volumetric standard that is accurate to within 0.1 percent and traceable to NIST*. Manufacturer's certificate of calibration provided with each flow meter. Accuracy within plus or minus 0.5 percent of rate at the calibrated velocity, within plus or minus 1 percent of rate over a 10:1 turndown (3.0 to 30 ft/s) and within plus or minus 2 percent of rate over a 50:1 turndown (from 0.4 to 20 ft/s). The flow meter to include integral analog output(s), 4-20 mA, 0-10V, or 0-5V. Bi-directional meters to include an isolated contact closure output for direction. Flow meter covered by the manufacturer's two year warranty.

I. Room Pressure Monitor: Active room pressure monitor and alarm which provides local audio alarm and analog and alarm signals to DDC system. Wall mounted panel with LED differential pressure readout; audible and visual alarm; mute button; range of -0.05 to +0.05-inch WC; accurate to 1 percent of full scale; repeatability plus or minus 1.0 percent of full scale per year, alarm delay ability between 0-30 seconds. Provide door switch to deactivate alarm when space door(s) are open. Input status from BAS to deactivate alarm in unoccupied or shutdown modes. Phoenix Controls APM100.

J. Wall Mounted Space Carbon Dioxide Sensor:
1. Sensor to employ non-dispersive infrared technology. (N.D.I.R.)
2. Sensor Repeatability: Plus or minus 20 ppm. 0-2000.
3. Sensor Accuracy: Less than or equal to 75 ppm over 0-1500 ppm range.
4. Sensor Response Time: Less than 1 minute.
5. Sensor to employ reference channel design for long-term stability.
6. Sensor to have field selectable 0-10VDC, or 4-20mA outputs.
7. Sensor power requirement less than 3W.
8. Sensor Input Voltage: 20 to 30VAC/DC.
9. Sensor Operating Temperature Range: 0 degrees C to 50 degrees C.
10. Sensor to have models for wall mounting or duct mounting.
11. Sensor to provide at least a 1-year factory warranty from date of purchase.
12. Sensor to match cover in color and look to temperature sensor.
13. Sensor to have display.
14. Manufacturers:
    a. Telaire
    b. Vaisala
    c. Veris

K. Paddle Type Flow Switches: Paddle type switches (water service only) UL listed, SPDT snap-acting with pilot duty rating (125 VA minimum) and have adjustable sensitivity with NEMA 1 enclosure.

L. Relays:
1. Control relays UL listed plug-in type with dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage to be suitable for application.
2. Time delay relays UL listed solid-state plug-in type with adjustable time delay. Delay adjustable plus or minus 200 percent (minimum) from setpoint or as indicated. Contact rating, configuration, and coil voltage to be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

M. Override Timers: Override timers spring-wound line voltage, UL Listed, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified. Timer suitable for flush mounting on control panel face and located on local control panels or where shown.

N. Current Transmitters:
1. AC current transmitters are self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit range compatible with actual applied span of current value, with internal zero and span adjustment and plus or minus 1 percent full-scale accuracy at 500 ohm maximum burden.
2. Transmitter meets or exceeds ANSI/ISA S50.1 requirements and UL/CSA recognized.
3. Unit split-core type for clamp-on installation on existing wiring.

O. Current Transformers: AC current transformers UL/CSA recognized and completely encased (except for terminals) in approved plastic material; plus or minus 1 percent accuracy at 5 A full-scale.

P. Voltage Transmitters: AC voltage; self-powered single-loop (two-wire) type; 4 to 20 mA output with zero and span adjustment; UL/CSA recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1. Ranges include 100 to 130 VAC, 200 to 250 VAC, 250 to 330 VAC, and 400 to 600 VAC full-scale, adjustable, with plus or minus 1 percent full-scale accuracy with 500 ohm maximum burden.

Q. Voltage Transformers: AC voltage transformers UL/CSA recognized, 600 VAC rated; built-in fuse protection; suitable for ambient temperatures of 40 degrees F to 130 degrees F; plus or minus 0.5 percent accuracy at 24 VAC and a 5 VA load.

R. Power Monitors: Selectable rate pulse output for kWh reading; 4-20 mA output for kW reading; N.O. alarm contact; ability to operate with 5.0 amp current inputs or 0-0.33 volt inputs; plus 1.0 percent full-scale true RMS power accuracy; plus 0.5 Hz, voltage input range 120-600 V, and auto range select; NEMA 1 enclosure. Current transformers having a 0.5 percent FS accuracy, 600 VAC isolation voltage with 0-0.33 V output. If 0-5 A current transformers are provided, a three-phase disconnect/shorting switch assembly is required.

S. Overflow Switch: Insertion flow sensor, brass, impeller flow design with analog transmitter unit. Data Industrial Model 220BR.

T. Ultrasonic Level Transmitter: Non-contact measuring device for liquid level; distance ranges from 4-feet to 32-feet; fail-safe intelligence with diagnostic feedback for troubleshooting; automatic temperature compensation; 24VDC; accuracy plus 0.15 percent of span in air. Kele LU Series.

U. End Switches: Turret head Type SPDT. Schneider Electric/Square D Class 9007, Type C54B2, or equal.

V. Condensation Sensor:
   1. Passive condensation sensor which will reliably and instantly indicate that condensation is occurring.
   2. Sensor to be able to indicate condensation prior to the condensation being visually perceptible and to last as long as any trace of condensation remains on the surface.
   3. Manufactured specifically for radiant cooling applications.
   4. Not dependent on dew point, humidity, or temperature determinations.
   5. Specifications (Based on Condenser):
      a. Mounting:
         1) The Model C condenser is mounted via its #8-32 x 3/8-inch non-metallic stud, nut and washer.
         2) A Pipe Adapter (Model PA-3) is available for mounting any condenser to a 1/8-inch to 3-inch OD pipe.
      b. Dimensions: Model C - Nom. 1.1-inch square footprint X 0.8-inch H from the mounting surface.
      c. Connection: Its 3 foot long cable is terminated in a MONO audio phone plug (1/8-inch / 3.5 mm for the Model C). Provide extensions to suit field conditions.
      d. Operating Temperatures: 5 to 70 degrees C.
      e. Humidity: Not a factor.
      f. Contaminants: Inert to materials other than plastic solvents. If it becomes contaminated with dust or other debris, typically, it is easily cleaned by flushing it with alcohol to restore it to service. Require no calibration.

g. Provide circuit module to provide binary input to the EMS/BAS with a "SENSOR FAULT."

6. Manufacturers:
   a. Model CG-ICM, no known equal.
   b. Or approved equivalent.

W. Wind Speed Sensor:
1. Low starting threshold.
2. Solid state light source and electronics.
3. Low profile to minimize “Sensor Turbulence.”
4. Calibrated to NIST secondary standard.
5. Quick-disconnect connector.
6. Internal heater for long bearing life.
7. Built-in electrical field surge protection.
8. Performance Characteristics:
   a. Maximum Operating Range: 0-125 mph (0-60 m/s).
   b. Starting Speed: 0.5 mph (0.22 m/s).
   c. Calibrated Range: 0-99 mph (0-50 m/s).
   d. Accuracy: Plus or minus 1 percent (0.15 mph).
   e. Temperature Range: -50 degrees C to 67 degrees C.
   f. Response: Distant constant less than 5-feet of flow.
9. Electrical Characteristics:
   a. Power Requirements: 12 VDC at 10 mA.
   b. Output Signal: 11 volt pulse.
   c. Output Impedance: 100 ohms maximum.
10. Physical Characteristics:
    a. Weight: 1.5 pounds (.68 kilogram).
    b. Finish: Anodized Aluminum.
    c. Mounting Fixtures: PN 191 Crossarm Assembly.
11. Accessories:
    a. PN 1953 Cable Assembly, vinyl jacketed shielded cable.
    b. Aluminum Cup Assembly, distance constant - 15-feet.
12. Manufacturers:
    a. Met One Instruments, Inc. - 010C
    b. Nova Lynx
    c. Or approved equivalent

X. Wind Direction Sensor:
1. Airfoil shaped polyurethane van assembly.
2. Components: Stainless steel.
3. Electrical Components: Field replaceable without requiring recalibration.
4. Single potentiometer for either 360 degree or 540 degree applications.
5. Low profile to minimize sensor turbulence.
6. High damping ratio.
7. Short relay distance.
8. Orientation lock.
9. Quick disconnect connector.
10. Internal heater for long bearing life.
11. Wind direction translator module.
12. Electrical field surge protection.
13. Performance Characteristics:
    a. Azimuth: Electrical - 0-357 degrees
    b. Azimuth: Mechanical - 0-360 degrees

c. Threshold: 0.5 mph
d. Linearity: Plus or minus 1/2 percent of full scale
e. Damping ratio: 0.25
f. Delay distance: Less than 3-feet.
g. Accuracy: Plus or minus 3 degrees
h. Temperature Range: -50 degrees C to 65 degrees C

14. Electrical Characteristics:
    a. Power Requirements: 12 VDC at 10 mA, 12 VDC at 350 mA for heater
    b. Output Signal: 0-5V volt
    c. Output Impedance: 100 ohms maximum
15. Physical Characteristics:
    a. Weight: 1.5 pounds (.68 kilogram)
    b. Finish: Anodized Aluminum
    c. Mounting Fixtures: PN 191 Crossarm Assembly
16. Accessories: PN 1953 Cable Assembly, vinyl jacketed shielded cable.
17. Manufacturers:
    a. Met One Instruments, Inc. - 010C
    b. Nova Lynx.
    c. Or approved equivalent.

Y. Rain Sensor:
1. Sensor is to be used to detect the onset of rainfall. A gold plated grid sensor activates the circuit when water is deposited onto the grid. The presence of water activates an internal relay that may be used in a Building Automation System.
2. An internal heater constantly dries the grid to prevent relay activation during times of dew, fog, or light moisture that is not actual precipitation. During periods of normal precipitation the heater is unable to dry the grid and the relay is activated. The heater power may be disconnected allowing the detector to be operated as a leaf wetness sensor.
3. The solid state electronics are mounted in a sealed weatherproof enclosure. The precipitation detector may be tilted to allow water to drain off. A mounting bracket is provided with the sensor to allow mounting onto a 1-inch pipe by a U-bolt. The wind screen must be used to prevent premature drying of the grid during precipitation events accompanied by high winds.
4. The unit requires plus 12 Vdc power for operation. A 115 Vac power adapter is provided with each unit. Power adapters for voltages other than 115 Vac are available upon request.
5. Specifications:
    a. Sensor: Gold plated grid 4-inch diameter.
    b. Output: Relay (0.5 amps).
    c. Heater: Resistive element.
    d. Power: 12 Vdc (235 mA max.) 115 Vac 60 Hz adapter supplied.
    e. Size: Overall 4-inch diameter x 2-inch high.
    f. Weight/Shipping: 4 lbs/5 lbs (1.8 Kg/2.3 Kg).
6. Manufacturers:
    a. NovaLynx Model 260-2590 Precipitation Detector
    b. Or approved equivalent.

2.15 WIRING AND RACEWAYS

A. General: Provide copper wiring, plenum cable, and raceways as specified in applicable Sections of Division 26, Electrical.

B. Insulated wire to be copper conductors, UL labeled for 90 degrees C minimum service.

C. Field panels and controllers to be supplied by building emergency power system where systems being monitored or controlled are on emergency power.

D. Run control wiring as follows:
   1. Mechanical Rooms: In conduit.
   2. Exposed in Building Spaces: In conduit.
   3. Concealed in Building Walls and Ceilings: Plenum rated cable.
   4. Concealed in Building Ceilings: Plenum rated cable in cable tray.

E. Field and Subfield Panels: Voltage in panels not-to-exceed 120 volts.

F. Motor Control Centers: Responsibility for correct voltage of holding coils and starter wiring in pre-wired motor control centers interfacing with automatic controls is included hereunder.

G. Wiring for BAS systems communications buses two conductor minimum 18 gauge foil-shielded, stranded twisted pair cable rated at 300 VDC or more than 80 degrees C.

2.16 SMOKE DETECTION (FOR PROJECTS WITH A FIRE ALARM SYSTEM)

A. See Division 28 for Products.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.

B. Notify the Owner's Authorized Representative in writing of conditions detrimental to the proper and timely completion of the work.

C. Do not begin work until unsatisfactory conditions are resolved.

3.2 CONTROL SYSTEM CHECKOUT AND TESTING

A. Testing completed before Owner's Authorized Representative is notified of system demonstration.

B. Calibrate and prepare for service of instruments, controls, and accessory equipment furnished under this specification.

C. Verify that control wiring is properly connected and free of shorts and ground faults.

D. Enable control systems and verify calibration and operation of input and output devices.

E. Verify that system operation adheres to sequences of operation.

F. Commissioning and Verification: In addition to commissioning requirements specified elsewhere, provide the following commissioning on the HVAC instrumentation and controls system:
   1. Control systems completely commissioned to ensure aspects of the system are operating as intended and at optimum tuning.

2. Wiring connections verified and traced from field device to panel to ensure proper connections.
3. Measured values verified by a hand held calibrated device to validate that value indicated by the control system is in fact the actual measured value.
4. Loops properly tuned to obtain the desired control value. Each loop to be "upset" and put back in control to demonstrate its ability to stabilize quickly.
5. Provide a final point-by-point report submitted that indicates the date of each verification, the results, and initialed on each page by the person performing the reading.

3.3 ACCEPTANCE TESTING AND TRAINING

A. Site Testing:
1. Contractor provides personnel, equipment, instrumentation, and supplies necessary to perform testing. Owner or Owner's Authorized Representative will witness and sign off on acceptance testing.
2. Contractor demonstrates compliance of completed control system with Contract Documents. Using approved test plan, physical and functional requirements of project demonstrated.

B. Training:
1. General: Contractor conducts training courses for up to three other designated personnel in operation and maintenance of system. Training manuals provided for each trainee, with two additional copies provided for archival at project site. Manuals include detailed description of subject matter for each lesson. Copies of audiovisuals delivered to Owner. Training day is defined as 8 hours of classroom instruction, including two 15-minute breaks and excluding lunch time, Monday through Friday, during normal first shift in effect at training facility. Notification of any planned training given to Owner's Authorized Representative at least 15 days prior to training.
2. Operator's Training I: First course taught at supplier's facility for period of one training day. Upon completion, each student should be able to perform elementary operations with guidance and describe general hardware architecture and functionality of system.
3. Operator's Training II: Second course taught at project site for a period of one training day after completion of contractor's field testing. Course includes instruction on specific hardware configuration of installed system and specific instructions for operating installed system. Upon completion, each student should be able to start system, operate the system, recover system after failure, and describe specific hardware architecture and operation of system.
4. Operator's Training III: Third course taught at project site for period of one training day no later than six months after completion of the acceptance test. Course will be structured to address specific topics that students need to discuss and to answer questions concerning operation of system. Upon completion, students should be fully proficient in system operation and have no unanswered questions regarding operation of installed system.

3.4 WIRING

A. Provide electrical wiring required to control systems specified in this Section. Control and interlock wiring complies with national, state and local electrical codes and Division 26, Electrical of this specification.

B. Power wiring required for building control panel(s) to be dedicated circuit(s).

C. Verify location of operator work station with Owner prior to installation.

D. NEC Class 1 (line voltage) wiring UL Listed in approved raceway according to NEC and Division 26, Electrical requirements.

E. Low-voltage wiring meets NEC Class 2 requirements. (Low-voltage power circuits subfused when required to meet Class 2 current limit.)

F. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for intended application.

G. Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for purpose of interfacing (e.g., relays and transformers).

H. Where Class 2 wiring is run exposed, wiring run parallel along surface or perpendicular to it and tied at 10 foot intervals.

I. Where plenum cables are used without raceway, support from structural members. Do not support cables with ductwork, electrical raceways, piping, or ceiling suspension systems.

J. Make wire-to-device connections at terminal block or terminal strip. Make wire-to-wire connections at terminal block.

K. Maximum allowable voltage for control wiring 24 V. If only higher voltages are available, provide step-down transformers.

L. Wiring installed as continuous lengths, with no splices permitted between termination points.

M. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at penetrations.

N. Include one pull string in each raceway 1-inch or larger.

O. Control and status relays are to be located in designated enclosures. Enclosures include packaged equipment control panels unless they also contain Class 1 starters.

P. Install raceway to maintain a minimum clearance of 6-inches from high-temperature equipment (e.g., steam pipes or flues).

Q. Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

R. Install insulated bushings on raceway ends and openings to enclosures. Seal top end of vertical raceways.

S. Flexible metal raceways and liquid-tight, flexible metal raceways not-to-exceed 3-feet in length and be supported at each end. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways to be used.

T. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections joined with couplings. Terminations made with fittings at boxes.

U. Input and output terminations to be labeled at the controller to identify if they are AI, DI, AO, DO, and function (i.e. pump start, OM Sensor).

3.5 COMMUNICATION WIRING

A. Follow manufacturer's installation recommendations for communication cabling.

B. Verify integrity of network following cable installation.

C. Communication wiring unspliced length when that length is commercially available; labeled to indicate origination and destination data.

D. Grounding of coaxial cable in accordance with NEC regulations article on “Communications Circuits, Cable, and Protector Grounding.”

3.6 INSTALLATION OF AUXILIARY CONTROL DEVICES

A. General:
1. Install sensors and thermostats in accordance with manufacturer's recommendations.
2. Room sensors and thermostats installed at 48-inches AFF to midline of sensor on concealed junction boxes properly supported by wall framing at the locations shown on the Drawings.
3. Low-limit sensors used in mixing plenums installed in a serpentine manner horizontally across duct.
4. Pipe-mounted temperature sensors installed in wells with heat-conducting fluid in thermal wells.
5. Install outdoor air temperature sensors on north facing wall or screen, complete with sun shield at designated location.

B. Flow Switch: Use correct paddle for pipe diameter. Adjust flow switch in accordance with manufacturer's instructions.

C. Actuators:
1. General:
   a. Mount and link control damper actuators according to manufacturer's instructions.
   b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
2. Actuator Mounting for Damper and Valve Arrangements to Comply with the Following:
   a. Damper Actuators: Do not install in the air stream.
   b. Use a weather proof enclosure (clear and see through) if actuators are located outside.
   c. Damper or valve actuator ambient temperature not-to-exceed 122 degrees F through any combination of medium temperature or surrounding air. Provide appropriate air gaps, thermal isolation washers or spacers, standoff legs, or insulation as necessary. Mount per manufacturer's recommendations.
   d. Actuator cords or conduit to incorporate a drip leg if condensation is possible. Do not allow water to contact actuator or internal parts. Location of conduits in temperatures dropping below dew point to be avoided to prevent water from condensing in conduit and running into actuator.
   e. Damper mounting arrangements to comply with the following:
      1) Furnish and install damper channel supports and sheet metal collars.
      2) Jack shafting of damper sections not allowed.

3) Multi-section dampers arranged so that each damper section operates individually. Provide one electronic actuator direct shaft mounted per section.

f. Size damper sections based on actuator manufacturers specific recommendations for face velocity, differential pressure and damper type. In general: Damper section not-to-exceed 24 ft-sq. with face velocity 1500 FPM.

g. Multiple section dampers of two or more arranged to allow actuators to be direct shaft mounted on the outside of the duct.

h. Multiple section dampers of three or more sections wide arranged with a 3-sided vertical channel (8-inch wide by 6-inch deep) within the duct or fan housing and between adjacent damper sections. Vertical channel anchored at the top and bottom to the fan housing or building structure for support. Connect sides of each damper frame to the channels. Holes in the channel to allow damper drive blade shafts to pass through channel for direct shaft mounting of actuators. Face open side of channel downstream of the airflow, except for exhaust air dampers.

i. Multiple section dampers to be mounted flush within a wall or housing opening to receive either vertical channel supports as described above or sheet metal standout collars. Sheet metal collars (12-inch minimum) to bring each damper section out of the wall to allow direct shaft mounting of the actuator on the side of the collar.

D. Control Valve:

1. Valves installed in accordance with manufacturer's recommendations.
2. Slip-stem control valves installed so that stem position is not more than 60 degrees from vertical up position. Ball type control valves installed with stem in horizontal position.
3. Control valves accessible and serviceable.
4. Install isolation valves so that control valve may be serviced without draining supply/return side piping system. Install unions at connections to screw-type control valves.
5. Valve Sizing for Water Coil:
   a. On/Off Control Valves: Line size.
   b. Modulating control valve body size may be reduced, at most, two pipe sizes from the line size or not less than 1/2 the pipe size. BAS contractor to size water coil control valves for the application as follows:
      1) Booster-heat valves sized not-to-exceed 4-9 PSI differential pressure. Size valve for 50 percent valve authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.
      2) Primary valves sized not-to-exceed 5-15 PSI differential pressure. Size valve for 50 percent valve authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.
      3) Butterfly valves sized for modulating service at 60 to 70 degree rotation. Design velocity 12-feet per second or less when used with standard EPDM seats.
   c. Valve Mounting Arrangements to Comply with the Following:
      1) Provide unions on ports of two-way and three-way valves.
      2) Install three-way equal percentage Characterized Control valves in a mixing configuration with the “A” port piped to the coil.
      3) Install 2-1/2-inch and above, three-way globe valves, as manufactured for mixing or diverting service to the coil.

E. Control Damper:

1. Dampers installed in accordance with manufacturer's instructions. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
2. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

F. Air Flow Station: Install where indicated in ductwork and/or equipment with manufacturer's recommended straight ductwork upstream and downstream of air flow station or as shown on drawings, whichever is greater. Where equipment manufacturer's standard airflow measuring station cannot read airflows at required design velocities, provide appropriate air flow measuring station to provide accurate reading throughout system design operations range.

3.7 SMOKE DETECTION (FOR PROJECTS WITH A FIRE ALARM SYSTEM)

A. Smoke detector furnished and powered/wired under Division 28, Electronic Safety and Security. Coordinate with fire alarm equipment supplier. Installation of duct smoke detector housing and sampling tube under Division 23, HVAC.

B. Install smoke detectors in supply air systems greater than 2000 CFM.

3.8 SEQUENCES OF OPERATION AND POINTS LISTS

A. Where local energy code dictates certain sequences (such as night setback, night flush, pressure and temperature reset, terminal unit sequences, etc.), the sequences are not necessarily repeated in the documents. It is not the intent of this specification or documentation to reiterate the energy code. Provide energy code mandated sequences and document in sequence of operations submittals at no additional cost to the Owner. Provide required points to achieve the appropriate sequences.

B. See control diagrams and sequences on drawings.

C. Variable Frequency Drives: For a VFD dependent on an external input for its output setting (e.g., the VFD gets “Frequency” as an input), loss of that external input to result in the VFD holding its last value. If the VFD is running its own PID loop and the external input to the VFD is a setpoint (e.g. duct static pressure setpoint), the VFD to hold the last setpoint. If the VFD loses its process variable (e.g. duct static pressure), the VFD to go to its minimum speed setting.

D. Except as specified otherwise, throttling ranges, proportional bands, and cycle differentials to be centered on the associated setpoint. Modulating feedback control loops to include the capability of having proportional, integral, and derivative action. Unless the loop is specified “proportional only” or “P+I”, Contractor to apply appropriate elements of integral and derivative gain to each control loop to result in stable operation, minimum settling time and maintain the primary variable within the specified maximum allowable variance.

E. Provide a real time clock and schedule controller with sufficient scheduling capability to schedule required controllers and sequences. Schedule functionality may reside in a controller. If a controller is used, document scheduling functionality including names and types on controller points list submittal. Set up initial schedules in coordination with Owner.

F. Scheduling Terminology: When air handlers are scheduled throughout the day, the following defines the terminology used:
   1. Occupied Period: Period of time when the building is in use and occupied. Confirm schedule with Owner. Exclude all national holidays. Generally systems will be fully operational throughout this period and ventilation air to be continuously introduced. Space temperature setpoints will generally be in the “normal” range of 68 degrees to 78 degrees F.
   2. Unoccupied period: Period of time when the building or zone is not in use and unoccupied. Ventilation air not to be introduced.
   3. Preoccupancy Period: Time prior to the Occupied period when the systems are returning the space temperatures from setback to “normal” or occupied setpoints (warm-up and

cool-down). Ventilation air shall not be introduced unless outside air conditions permit free-cooling or to support a pre-occupancy purge sequence. Time period to be determined by an optimum start strategy unless otherwise specified.

4. Setback Period: Setback will typically start with the end of the occupied period and end with the start of the preoccupancy period, however it shall be provided with its own schedule. Generally systems will be off except to maintain a “setback” temperature, economization may be enabled to maintain “setback” cooling setpoint when applicable.

G. Where any sequence or occupancy schedule calls for more than one motorized unit to start simultaneously, the BAS start commands to be staggered by 5 second (adj.) intervals to minimize inrush current.

H. Wherever a value is indicated as adjustable (adj.), it shall be modifiable, with the proper password level. For these points, it is unacceptable to have to modify programming statements to change the setpoint.

I. When a power failure is detected in any phase, the BAS start commands to be retracted immediately from electrically powered units served by the failed power source. If the associated controller is powered by normal or emergency power, it may monitor its own power source as an indication of power status. If the controller is powered by uninterruptible power supply (UPS), or if it is not capable of monitoring its own power for use in sequences, provide at least one voltage monitor (three phase when applicable) per building. When the BAS detects that normal or emergency power has been restored, all equipment for which the BAS start command had been retracted to be automatically restarted in an orderly manner on staggered 5 second intervals to minimize inrush current.

J. Where reset action is specified in a sequence of operation, but a reset schedule is not indicated on the drawings, employ one of the following methods:

1. Determine a fixed reset schedule to result in stable operation and maintain the primary variable within the specified maximum allowable variance.
2. Use a floating reset algorithm which increments the secondary variable setpoint (setpoint of control loop being reset) on a periodic basis to maintain primary variable setpoint. The recalculation time and reset increment to be chosen to maintain the primary variable within the specified maximum allowable variance.
3. Primary variable to control the devices directly using a PID feedback control loop without resetting the secondary variable. However, the control devices to still modulate as necessary to maintain upper and lower limits on the secondary variable. Proportional band, integral gain, and derivative term to be selected to maintain the primary variable within the specified maximum allowable tolerance while minimizing overshoot and settling time. Gain prior approval for implementing this method of reset.

K. Where a supply air temperature or duct pressure setpoint is specified to be reset by the space temperature of the zones calling for the most cooling/heating, employ the following method:

1. Use a floating reset algorithm which increments the secondary variable (e.g., supply air temperature or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g., space temperature) setpoint. The reset increment to be determined by the quantity of “need heat” or “need cool” requests from individual SCU's. A SCU's “need heat” virtual point to activate whenever the zone's space temperature falls below the currently applicable (occupied or unoccupied) heating setpoint throttling range. A SCU's “need cool” virtual point to activate whenever the zone's space temperature rises above the currently applicable (occupied, unoccupied, or economy) cooling setpoint throttling range. The recalculation time and reset increment to be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and settling time. Reset range maximum and minimum values to limit the setpoint range.

L. Where a supply air temperature, duct pressure, or differential water pressure setpoint is specified to be reset by valve or damper position of the zone or zones calling for the most cooling/heating, the following method to be employed:
   1. A floating reset algorithm to be used which increments the secondary variable (e.g., supply air temperature, pipe or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g., cooling valve, heating valve, damper position) setpoint of 85 percent open. The reset increment to be calculated based on the average position of the quantity of the worst (most open valve/damper) zone(s) as specified. The recalculation time, reset increment and control device position influence to be chosen to maintain the primal variable within the specified maximum allowable variance while overshoot and settling time. The BAS analog output value to be acceptable as indicating the position of the control device.
   2. Alternatively to continuously calculating the average of the quantity of worst valve/damper positions, a method similar to the one described above may be employed whereby the “need heat” or “need cool” virtual point to increment by one unit each time a zone's valve/damper position rises to greater than 95 percent. The quantity of “need heat” or “need cool” points to then be the basis for reset.

M. Where “prove operation” of a device (generally controlled by a digital output) is indicated in the sequence, it shall require that the BAS, after an adjustable time delay after the device is commanded to operate (feedback delay), confirm that the device is operational via the status input. If the status point does not confirm operation after the time delay or anytime thereafter for an adjustable time delay (debounce delay) while the device is commanded to run, an alarm to be enunciated audibly. Upon failure, run command to be removed and the device to be locked out until the alarm is manually acknowledged unless specified otherwise.

N. BAS to provide for adjustable maximum rates of change for increasing and decreasing output from the following analog output points:
   1. Speed control of variable speed drives
   2. Control Reset Loop
   3. Valve Travel Limit

O. Wherever a value is indicated to be dependent on another value (i.e., setpoint plus 5 degrees F) BAS to use that equation to determine the value. Simply providing a virtual point that the operator must set is unacceptable. In this case three virtual points to be provided. One to store the parameter (5 degrees F), one to store the setpoint, and one to store the value which is the result of the equation.

P. Trend points as identified in the points list. Trends to be grouped system specific and setup in two-axis (x,y) graphical format that display object values relative to time. Setup trends to record data in 5 minute increments.

Q. Sequence of Operations for Air Handling Units
   1. Occupied Mode:
      a. General:
         1) Initiate occupied mode from BAS schedule.
         2) Open fire and smoke dampers in distribution ductwork. After 60 second delay start fans to allow fire and smoke dampers to open without causing duct damage.
         3) Fans run continuously.
         4) Open outdoor air damper or minimum outdoor air damper position and reset minimum outdoor air quantity to minimum Demand Control Ventilation (DCV) air quantity position where a DCV value is shown on Schedules.
   2. Economizer operation with Return Fan:

a. Implement the following, in sequence, to maintain unit's supply air temperature setpoint.
    1) Fully open outdoor air damper.
    2) Modulate return air damper.
    3) Modulate relief air damper in reverse of return air damper.

3. Economizer operation with Gravity Relief Damper
    a. Implement the following, in sequence, to maintain unit's supply air temperature setpoint.
        1) Open relief air damper, if motorized.
        2) Return air damper to be fully open.
        3) Modulate outdoor air damper until fully open.
        4) Modulate return air damper until fully closed.
4. Supply Air Temperature Control with Chilled Water Coil
    a. When outdoor air temperature is higher than return air temperature, disable economizer operation and modulate chilled water control valve to maintain supply air temperature setpoint.
    b. When outdoor air temperature is less than return air temperature, initiate economizer operation as first stage of cooling.
    c. As second stage of cooling modulate chilled water control valve.
    d. When outdoor air temperature is less than supply air temperature setpoint modulate heating hot water control valve to maintain supply air temperature set point.
    e. Supply air temperature setpoint to have 4 F deadband.
5. Supply Air Temperature Control for with Chilled Water Coil for 100 Percent Outdoor Air Units
    a. When supply air temperature is above setpoint, modulate chilled water control valve to maintain supply air temperature set point.
    b. When supply air temperature is below setpoint modulate heating hot water control valve to maintain supply air temperature set point.
    c. Supply air temperature setpoint to have 4 F deadband.
6. Supply Air Temperature Setpoint Reset
    a. When unit is enabled in occupied mode initially SAT setpoint set at 70 degrees F
    b. If any zone has a cooling demand above 10 percent set the SAT setpoint at 68 degrees F (adj).
    c. If the total number of zones with 100 percent cooling demand is greater than one reset the SAT setpoint down 1 degree F every five minutes (adj) to a minimum of 55 degrees F (adj).
    d. If the total number zones with 100 percent cooling demand is zero, then reset SAT setpoint up 1 degrees F every five minutes (adj) to a maximum of 68 degrees F.
    e. If the total number zones with a cooling demand greater than 10 percent is zero set the SAT setpoint at 70 degrees F (adj).
7. Fan Speed Control for Air Handling Units with VFDs
    a. Vary fan speed by the following methods, as applicable:
        1) Determine minimum fan speed in cooperation with the test and balance agent, with an initial speed of 20 percent of unit's peak design speed. Limit fan speed change 10 percent per minute (adj).
        2) For fans/ fan systems with one VFD, vary VFD frequency to maintain setpoint, with minimum speed as determined above.
        3) For fans/ fan systems with multiple VFDs including a standby VFD, vary frequency of non-standby VFDs in unison to maintain setpoint, with minimum speed as determined above. Shut down lag VFD when the speed of VFDs is at minimum, and turn on the lag VFD(s) when the speed of operating VFD(s) is at 85 percent of peak speed. On failure of lead VFD, shut down lead VFD and turn on lag VFD in sequence with standby VFD, via BMS and through hardwire connection between VFDs.

4) For units with multiple VFDs, without a standby VFD, vary the speed of VFDs in unison. Shut down lag VFD when the speed of VFDs is at minimum, and turn on the lag VFD(s) when the speed of operating VFD(s) is at 85 percent of peak speed or at failure of lead fan(s) or lead VFD. On failure of lead fan(s) or lead VFD shut down lead VFD and start lag VFD through hardwire connection between VFDs.
5) For units with multiple fans with ECM motors, vary the speed of motors in unison to maintain setpoint, and maintain minimum speed as determined above. Shut down fan(s) in sequence when fan(s') speed is less than 20 percent above fan(s') minimum speed. Start fan(s) in sequence when the speed of operating fan(s) is at or above 85 percent of peak speed. On failure of individual fans as determined by each fan's dry contact, start a lag fan and standby fan, in sequence, as applicable.
6) Display total air quantity delivered by fans with ECM motors, at the unit's graphic display screen, and provide additional screens/tables to display air quantity of all fans in an air handling unit with multiple fans with ECM motors.

8. Medium Pressure Supply Air Duct Static Pressure Setpoint Reset
   a. Reset supply air duct static pressure setpoint between 0.15-inch (adj) and scheduled maximum unit ESP (adj), using Trim and Respond logic in conjunction with terminal units' pressure requests, with the high static pressure setpoint determined in cooperation with test and balance agent.
   b. Provide a means to automatically identify rogue zones and eliminate them from the logic by assigning an Importance Factor of zero. Rogue Zones are zones with Cumulative-Request-Hours of greater than 70 percent, with Cumulative-Request-Hours, expressed as a percentage, defined as:
      1) Zone Request Hours divided by the zone run-hours.
      2) Zone run-hours is defined as hours in any Mode other than Unoccupied Mode since the last reset.
   c. Provide trending of individual zone's damper position, pressure request, and Cumulative-Percent-Request-Hours.
   d. When unit is enabled in any mode, set initial supply air static pressure setpoint at 0.5-inch (adj).
9. Medium Pressure Supply Air Duct Static Pressure Control
   a. Modulate supply fan speed to maintain duct pressure setpoint at remote duct static pressure sensor located downstream of supply fan at approximately 2/3 length of medium pressure ductwork.
   b. If duct static pressure is 1-inch below the SMACNA duct rating class for which the ductwork was designed for, generate an alarm and do not increase supply fan speed until duct static pressure is below this value.
   c. If duct static pressure is 0.5-inch below the SMACNA duct rating class, generate an alarm and shut down fans through a hardwire connection.
10. Raised Floor Static Pressure Control
    a. Modulate zone supply dampers to maintain raised floor static pressure setpoint of 0.06-inch (adj) at each zone.
11. Building Static Pressure Control with Return Fan
    a. Modulate fan speed to maintain building static pressure of 0.05-inch positive (adj) relative to outdoors.
    b. Open relief air damper to fully open position when fan operates. Provide 15-second delay in fan start/stop to allow damper to open/close without causing duct damage.
    c. If return fan is at minimum speed, modulate relief damper to maintain building static pressure setpoint.
12. Minimum Outdoor Air Quantity Setpoint

a. Minimum outdoor air quantity setpoint is the lesser of MIN OSA or DCV MIN (where indicated), as indicated on Schedules and as reset by Demand Control Ventilation algorithm, as applicable.

13. Demand Control Ventilation
    a. If the unit is supplying only one zone, and that zone has CO2 monitoring sensor(s), and CO2 level is above 900 ppm (adj), gradually increase minimum outdoor air quantity setpoint from DCV MIN to MIN OSA value to maintain a maximum CO2 concentration of 1,000 ppm. Generate an alarm if the zone's CO2 concentration is greater than 1,200 ppm (adj).
    b. If there are any rooms/zones with a CO2 sensor, execute Demand Control Ventilation (DCV) control strategy at the zone level. If the zone's DCV control strategy has been executed and any zone's CO2 level is above 900 ppm (adj), gradually increase minimum outdoor air quantity setpoint from DCV MIN to MIN OSA value to maintain a maximum CO2 concentration of 1,000 ppm.
    c. Provide adequate time delay, to be determined in cooperation with the test and balance agent, to avoid false alarms and adequate time for system to balance during sudden loading of space.
14. Minimum Outdoor Air Control with Airflow Measuring Station
    a. Enable minimum outdoor airflow control when unit is not in economizer mode.
    b. Modulate outdoor air damper and return air damper, in sequence, to maintain minimum outdoor airflow setpoint.
15. Shutdown Mode
    a. Shut down unit according to BAS schedule or if required due to safeties, and:
        1) Disable fans.
        2) Close outdoor and relief air dampers.
        3) Open return air damper.
        4) Close chilled water control valve.
        5) Close heating water control valve.
        6) 60 seconds (adj) after fan shutdown close fire and smoke dampers in distribution ductwork.
16. Unoccupied Mode
    a. General
        1) Shut down unit unless enabled in Night Setback, Night Setup, Night Purge or Unoccupied Override mode.
17. Night Setback
    a. Night Setback does not apply to 100 percent outdoor air units without a return air connection.
    b. When any space temperature drops 2 F (adj) below heating setpoint temperature:
        1) Run fans.
        2) Outdoor and relief air dampers remain closed and return air dampers remains open.
        3) Modulate heating hot water control valve, to maintain discharge air temperature setpoint of 90 F (adj).
        4) Shutdown unit when lowest space temperature is 2 F (adj) above heating setpoint.
18. Night Set-up
    a. Night Set-up does not apply to 100 percent outdoor air units without a return air connection.
    b. When any space temperature rises 2 F (adj) above cooling setpoint temperature:
        1) Run unit and interlocked fans.
        2) Relief fan or exhaust fan interlocked with the unit remain off.
        3) Outdoor and relief air dampers remain closed and return air damper remains open, unless in economizer mode.

4) If outdoor air temperature is higher than return air temperature disable economizer mode and modulate chilled water control valve, where applicable, to maintain design supply air temperature (adj).
5) If outdoor air temperature is less than return air temperature enable economizer operation as first stage of cooling followed by modulate chilled water control valve to maintain design cooling supply air temperature.
6) Shutdown unit when highest space temperature is 2 F (adj) below cooling temperature setpoint.

19. Night Purge
    a. Begin Night purge modes when all the following conditions are met:
        1) Peak outdoor air temperature in previous 24 hours has exceeded 80 F (adj).
        2) Unit is less than 5 hours (adj) from occupancy.
        3) Space temperature is above 68 F (adj) in more than 2 zones.
        4) Outdoor air temperature is above 45 F (adj) and below 65 F (adj).
    b. For Night Purge operation:
        1) Disable morning warmup prior to occupancy.
        2) Run unit and fans, as applicable.
        3) Enable economizer mode and maintain supply air temperature setpoint of 50 F (adj).
        4) Disable mechanical cooling and heating systems.
        5) Reset room cooling temperature setpoint to 65 F (adj) until scheduled occupancy.
    c. Terminate night purge when one of the following occurs:
        1) Zone is less than 20 minutes (adj) from occupancy.
        2) Return air temperature is less than 65 F (adj).
20. Unoccupied Override
    a. Divide the areas served by the unit into Override Zones with each zone containing one or more terminal control units. Grouping of terminal units into Override Zones to be determined by the Owner and easily changeable by the Owner. Provide a graphical representation of Override Zones with the ability of assigning/re-assigning zones/terminal units to Override Zones without leaving the current screen.
    b. When an override signal from a space temperature sensor has been received, enable all terminal units within the Override Zone which the space temperature sensor is a part of, and disable all other terminal units, except enable adequate number of additional Override Zones to satisfy the minimum air quantity requirements of the unit.
    c. Initiate Occupied Mode upon receiving an override signal from designated space temperature sensors.
    d. Initiate Unoccupied Mode when one of the following occurs.
        1) Timed override period of 2 hours (adj) has expired.
        2) Timed override is cancelled.
21. Morning Warm-up
    a. Initiate Morning Warm-up mode using an optimal start algorithm that uses an adaptive learning feature that automatically adjusts the morning warm-up start time so that the average zone temperature in the exterior zones is 68 F (adj) at the start of scheduled occupied period.
    b. During morning warm-up operation:
        1) Unit and applicable fans operate.
        2) Outdoor and relief dampers are closed.
        3) Return air damper is open.
        4) Mechanical cooling is de-energized.
        5) Modulate heating control valve, as applicable, to maintain supply air temperature setpoint of 90 F (adj).
22. Morning Warm-up with Pre-Occupancy Purge

a. Initiate Morning Warm-up mode using an optimal start algorithm that uses an adaptive learning feature that automatically adjusts the morning warm-up start time so that the average zone temperature in the exterior zones is 68 F (adj) at the start of scheduled occupied period.
b. During morning warm-up operation:
    1) Unit and applicable fans operate.
    2) Outdoor and relief dampers are closed.
    3) Return air damper is open.
    4) Mechanical cooling is de-energized.
c. Modulate heating control valve, as applicable, to maintain supply air temperature setpoint of 90 F (adj).
d. Initiate Pre-occupancy Purge Mode one hour prior to start of occupancy.
e. During Pre-occupancy Purge operation:
    1) Enable unit to Occupied mode and set the Minimum Outdoor Air quantity setpoint to the lesser of MIN OSA cfm or 3 air changes per hour for all areas served by the unit.
f. Reset space heating and cooling temperature setpoints to 68 F and 78 F, respectively.

23. Pre-occupancy Purge
    a. Initiate Pre-occupancy Purge Mode one hour prior to start of occupancy.
    b. During Pre-occupancy Purge operation:
        1) Enable unit to Occupied mode and set the Minimum Outdoor Air quantity setpoint to the lesser of MIN OSA cfm or 3 air changes per hour for all areas served by the unit.
        2) Reset space heating and cooling temperature setpoints to 68 F and 78 F, respectively.
24. Morning Cool-Down:
    a. Morning cool-down does not apply to 100 percent outdoor air units without a return air connection.
    b. Initiate Morning Cool-down mode using an ‘optimal’ start algorithm that uses an adaptive learning feature that automatically adjusts the Morning Cool-down start time so that the average zone temperature in the exterior zones is 78 F (adj) at the scheduled occupied start time.
    c. During Morning Cool-down operation:
        1) Unit and applicable fans operate.
        2) Outdoor and relief dampers are closed, except when in economizer mode.
        3) Return air damper is open.
        4) Heating system is disabled.
        5) If outdoor air temperature is higher than return air temperature disable Economizer mode and modulate chilled water control valve, where applicable, to maintain scheduled supply air temperature.
        6) If outdoor air temperature is less than return air temperature, enable Economizer mode as first stage of cooling followed by: modulate chilled water control valve, where applicable.
25. Fire Mode for Low Rise Buildings:
    a. Generate an alarm on activation of Fire signal from Fire Alarm Control Panel.
    b. Maintain operational mode of the unit, unless shut down due to safeties.
26. Freeze Protection:
    a. Enable Freeze Protection during all modes of operation.
    b. If supply air temperature is at or below 40 F for longer than 5 minutes generate an alarm.
    c. Open the hot water valve and ensure the heating hot water system is active.
27. Alarms / Safeties:
    a. Generate an alarm if any of the following conditions occur:

1) Smoke is detected in the supply air duct(s) as shown on control drawings and/or Points Lists. Shutdown unit through a hardwire connection.
2) Static pressure at the discharge of the unit exceeds alarm setpoint
3) Shut down unit and generate an alarm when the high limit pressure switch at the discharge of the unit is activated.
4) Low limit detection thermostat located upstream of cooling coil senses air temperature below 36 degrees F and shuts down unit through hardwire connection.
5) Differential pressure sensors located across each filter bank is activated when static pressure drop exceeds the following values:
   (a) For a pre-filter only, up to 4-inches depth: 0.50-inches (adj).
   (b) For a minimum 12-inches deep final filter only: 1.25-inches (adj).
   (c) For a pre-filter and final filter: 1.50-inches (adj).
6) Static pressure at the inlet to the return fan exceeds the lesser of negative 2.0-inches (adj).
7) Static pressure at the inlet to the return fan exceeds the lesser of negative 2.5-inches. Shutdown air handling unit.
8) Any fan's VFD or ECM motor signals an alarm.

R. Global Sequence of Operations:
   1. Include the following sequences in the BAS catalog of routines and execute when called upon by specific equipment. Mode of operation of units is initiated from BAS schedule.

S. Air Handling Unit - Variable Air Volume with Hydronic Coils:
   1. Refer to "Global Sequence of Operations for Air Handling Units" article for definition of various modes of operation indicated herein. Mode of operation of units is initiated from BAS schedule.
   2. Unit to operate under following modes:
   3. Occupied Mode - OM-AHU-1:
   4. Economizer operation - EM-AHU-1
   5. Supply Air Temperature Control - SAT-C-AHU-1
   6. Supply Air Temperature Control for 100 percent Outdoor Air Units - SAT-C-AHU-OA-1
   7. Supply Air Temperature Setpoint Reset - SAT-Reset-1
   8. Fan Speed Control for Air Handling Units - FSC-AHU-1
   9. Medium Pressure Supply Air Duct Static Pressure Control - MP-DSP-AHU-1
   10. Medium Pressure Supply Air Duct Static Pressure Setpoint Reset - MPDSP-reset-1
   11. Raised Floor Static Pressure Control - RFSP-C-AHU-1
   12. Return Fan, or Exhaust Fan Building Static Pressure Control - RF-BSP-AHU-1
   13. Minimum Outdoor Air Quantity Setpoint - MOA-SP-1
   14. Demand Control Ventilation - DCV-AHU-1
   15. Minimum Outdoor Air Control with Mixed Air Plenum Pressure Control- MOA-MAPP-AHU-1
   16. Minimum Outdoor Air Control with Airflow Measuring Station - MOA-AFMS-AHU-1
   17. Minimum Outdoor Air Control with Minimum Outdoor Air Damper and Airflow Measuring Station - MOA-MOAD-AHU-1
   18. Shutdown Mode - SM-AHU-1
   19. Unoccupied Mode - UOCC-1
   20. Night Setback - NSB-AHU-1
   21. Night Setup - NSU-AHU-1
   22. Night Purge - NP-AHU-1
   23. Unoccupied Override - UO-1
   24. Morning Warm-up - MWU-AHU-1
   25. Pre-occupancy Purge - POCCP-1
   26. Morning Cool-down - MCD-AHU-1

27. Fire Mode for Low Rise Buildings - FM-LR-1
28. Freeze Protection - FP-AHU-1
29. Alarms / Safeties - AL-1
30. Alarms / Safeties - AL-AHU-1

T. Air Cooled Heat Recovery Heat Pump HP-1
   1. Heating or Cooling Mode
      a. Enable HP-1 mode when all the following is true:
         1) A definable number of chilled water or hot water coils need heating or cooling.
         2) Cooling mode has been disabled for minimum of 15 minutes (adj) only if HP-1 does not have internal control to limit restarts.
      b. Disable HP-1 when all chilled water and hot water control valves are closed.
   2. Chilled water & HHW systems' system differential pressure control - Primary Variable Flow Systems
      a. In sequence, modulate lead primary pump's speed, stage on/off lag primary pump(s) and run in unison with the lead pump to maintain differential pressure (DP) setpoint at the most remote control valve (adj), with DP setpoint determined in cooperation with the test and balance agent.
      b. For each CHwW and HHW system, if the respective pump's VFD speed is greater than 90-percent (adj) for 3 minutes, stage on lag pump, and open HP-1 evaporator and condenser isolation valve if HP-1's differential pressure exceeds a value corresponding to a flowrate of 10-percent above HP-1 design water flow rate.
      c. If pumps' VFD speed are below 45-percent (adj) for 3 minutes stage off respective lag pump.
      d. When the lag pump for CHW and/or HHW systems are started, ramp up the respective lag pump VFD speed to match the lead VFD speed and then run in unison to maintain differential pressure setpoint.
      e. Set the VFD minimum speed at a speed determined in cooperation with the test and balance agent and the pump and motor manufacturer.
   3. Chilled Water & Heating Hot Water Differential Pressure Reset
      a. Reset differential pressure setpoint between 1 psi (adj) and DP setpoint using Trim and Respond logic in conjunction with cooling coil control valves' pressure requests.
      b. Provide means to automatically identify rogue zones and eliminate them from the logic by assigning an Importance Factor of zero. Rogue Zones are zones with Cumulative-Request-Hours of greater than 70-percent, with Cumulative-Request-Hours, expressed as a percentage, defined as:
         1) Zone Request Hours divided by the zone run-hours.
         2) Zone run-hours is defined as hours in any Mode other than Unoccupied Mode since the last reset.
      c. Provide trending of individual zone's valve position, pressure request, and Cumulative--percent-Request-Hours.
      d. When unit is enabled in any mode, set initial differential pressure setpoint at 3 psi (adj).
   4. Chilled water & HHW system's minimum flow control
      a. Modulate minimum flow/differential pressure bypass control valve of each system to maintain differential pressure (DP) setpoint, minimum flow required to protect pumps, and minimum flow required by HP-1 as measured by differential pressure sensors across the evaporator and condenser.
   5. Heat Pump capacity control
      a. -1 is controlled by its stand-alone controller to maintain chilled water and heating hot water supply water temperature setpoint.
      b. Transmit CHW & HHW supply temperature setpoint to HP-1's controller.
   6. CHW & HHW Supply Temperature - Setpoint Reset:

a. Reset the Chilled Water Supply (CHWS) temperature setpoint using a trim and respond logic between design CHWS temperature and 5 F (adj) above design CHWS temperature in conjunction with cooling coil control valves' pressure requests.
b. As the outside air temperature varies from 60 deg F (adj) to the ASHRAE 1- percent winter design temperature, reset the heating hot water supply temperature setpoint from 20 F less (adj) than the design heating hot water supply temperature to the heating hot water supply temperature.
c. Provide means to automatically identify rogue zones and eliminate them from the logic by assigning an Importance Factor of zero. Rogue Zones are zones with Cumulative-Request-Hours of greater than 70-percent, with Cumulative-Request-Hours, expressed as a percentage, defined as:
    1) Zone Request Hours divided by the zone run-hours.
    2) Zone run-hours is defined as hours in any Mode other than Unoccupied Mode since the last reset.
d. Provide trending of individual zone's valve position, pressure request, and Cumulative--percent-Request-Hours.
e. On startup of HP-1, reset the CHWS temperature setpoint and HHWS temperature setpoint to the HP-1's maximum value (adj) and minimum value (adj), respectively, and gradually ramp down/up the setpoint from its maximum/minimum value to the previous CHWS/HHWS temperature setpoint. Minimum chilled water temperature is the design CHWS temperature (adj) unless reset as noted above. Maximum hot water temperature is the design HWS temperature (adj) unless reset as noted above.

7. Heat Pump Freeze Protection Mode:

a. Connect to HP-1 controller and monitor HP-1's water temperature inside the heat exchanger and HP-1's Low Temperature Warning Alarm. Enable Heat Pump freeze protection mode when Heat Pump's Low Temperature Warning Alarm is activated, HP-1's water temperature inside the heat exchanger is less than 38 degrees F, outdoor air temperature is less than 45 degrees F (adj) or chilled water or heating hot water supply or return temperature is less than 40 degrees F (adj). Generate an alarm when Heat Pump freeze protection mode is initiated.

b. When Heat Pump freeze protection mode is enabled, open the system differential pressure bypass valve, and start the system primary and secondary pumps and operate to maintain differential pressure setpoint across HP-1. Run pumps until the water temperature at heat exchanger is not less than 40 degrees F (adj) and HP-1's Low Temperature Warning Alarm is deactivated.

8. Alarms/Safeties:

a. Generate an alarm if any pump VFD speed feedback is less than 80-percent of command for 3 minutes, VFD status is lost for minimum 1 minute, VFD fault, drive failure, is off, or in hand.
b. Unit Status Display: Connect with HP-1's control panel, obtain all pertinent information and display the following minimum information at the Operator Workstation.
    1) System mode of the chiller plant
    2) Enable/disable status
    3) System CHW & HHW supply water temperature setpoint
    4) System CHW & HHW supply and return water temperature
    5) System CHW & HHW water pump status
    6) System CHW & HHW flow
    7) Current plant control operation
    8) System failure information
    9) HP-1's failure information
    10) Remove a pump from a sequence temporarily for service purposes.

11) High CHW & HHW Differential Pressure: If the CHW or HHW differential pressure is 25-percent (adj.) greater than setpoint.
12) Low CHW & HHW Differential Pressure: If the CHW or HHW differential pressure is 25-percent (adj.) less than setpoint.

c. Event Processing - Record HP-1's control and status events at the operator's selection, in the BAS event log to facilitate troubleshooting.
d. System Security - Provide program security designation for each operator with a choice of the following functions.
1) View HP-1's status
2) Change HP-1's plant status
3) View HP-1's plant setup
4) Change HP-1's plant setup
e. Alarm Indications - Display HP-1's plant and alarm messages at HP-1 plant control status screens.

U. Terminal Units with Hot Water Reheat (TU):
1. Occupied Mode:
a. Maintain space heating and cooling temperature setpoints by implementing the following routine, in sequence:
1) If space temperature is higher than cooling temperature setpoint, disable terminal unit's heating system and maintain cooling temperature setpoint by modulating damper from Minimum Heating airflow to Maximum Cooling airflow.
2) If space temperature is less than heating temperature setpoint, initiate first stage of heating at Minimum Heating airflow and modulate heating coil's control valve(s), as applicable, to gradually increase unit's supply air temperature setpoint from 80 to 95 F.
3) If space temperature is still less than heating temperature setpoint, confirm that the boiler plant is enabled and supply air temperature is above room setpoint and initiate second stage of heating by modulating damper from Minimum Heating airflow to Maximum Heating airflow while maintaining supply air temperature setpoint of 95 F.
4) If space temperature is still less than occupied heating setpoint temperature, initiate third stage of heating by modulating heating coil's control valve.
b. For zones with CO2 sensors, if space CO2 concentration is greater than 800 ppm (adj) modulate damper between Minimum Heating and Maximum Heating airflow setpoints to maintain maximum CO2 concentration of 900 ppm. Generate an alarm if the zone CO2 concentration is greater than 1,200 ppm (adj). Provide adequate delay (time determined during commissioning) to avoid false alarming and adequate time for system to balance during sudden loading of spaces.
2. Window Switch
a. For zones that have operable windows (at wall or roof) with indicator switches, when the window switch(es) indicates the window(s) is(are) open, initiate Unoccupied mode, ignore Unoccupied Override signals, and reset the zone heating temperature setpoint and the zone cooling temperature setpoints to 40 F and 120 F, respectively.
b. Generate an alarm if the zone temperature is 50 F or less.
c. Revert to normal setpoints when the window switch(es) indicate that window(s) is(are) closed.
3. Unoccupied Mode:
a. Close terminal unit damper and disable heating system. Ignore any signals from space occupancy or carbon dioxide sensors.
b. If space temperature is greater than unoccupied cooling temperature setpoint, and if central air handling unit is operating, modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.

c. If space temperature is less than unoccupied heating temperature setpoint, modulate damper between no airflow and Maximum Heating airflow setpoints, in sequence with modulating heating coil's control valve subject to a maximum discharge air temperature of 95 degrees F (adj.), as appropriate, to maintain space temperature at unoccupied heating setpoint.
d. During Unoccupied Mode, if any single zone falls below 40 F, generate an alarm and initiate Setback Mode until all zones are above 50 F.

4. Morning Warm-up Mode
   a. Modulate damper between no airflow and Maximum Heating airflow setpoints, in sequence with modulating heating coil's control valve subject to a maximum discharge air temperature of 90 degrees F (adj.) to maintain space temperature setpoint corresponding to the appropriate mode.
5. Night Setback Mode
   a. Modulate damper between no airflow and Maximum Heating airflow setpoints, in sequence with modulating heating coil's control valve subject to a maximum discharge air temperature of 90 degrees F (adj.) to maintain space temperature setpoint corresponding to the appropriate mode.
6. Morning Cool-down Mode:
   a. Modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.
7. Night Set-up Mode:
   a. Modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.
8. Night Purge Mode:
   a. Modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.
9. Pre-occupancy Purge Mode:
   a. One hour prior to occupancy operate the terminal unit at a minimum flowrate of 3 air changes per hour for all areas served by the unit and modulate terminal unit damper and HHW heating control valve, in sequence, to maintain corresponding cooling and heating temperature setpoints.
10. Unoccupied Override:
    a. When an override signal from a space temperature sensor has been activated, change the mode of the terminal unit to Occupied for 2 hours (adj).
    b. Terminate Unoccupied Override mode when one of the following occurs:
       1) Timed override period of 2 hours (adj) has expired.
          (a) Timed override is cancelled.

V. Terminal Units - Cooling Only (TU)
1. Occupied Mode:
   a. Maintain space heating and cooling temperature setpoints by implementing the following routine, in sequence:
      1) If space temperature is higher than cooling temperature setpoint, maintain cooling temperature setpoint by modulating damper from Minimum airflow to Maximum airflow.
   b. For zones with CO2 sensors, if space CO2 concentration is greater than 800 ppm (adj) modulate damper between Minimum and Maximum airflow setpoints to maintain maximum CO2 concentration of 900 ppm. Generate an alarm if the zone CO2 concentration is greater than 1,200 ppm (adj). Provide adequate time delay, to be determined in cooperation with the test and balance agent, to avoid false alarms and adequate time for system to balance during sudden loading of space.
2. Window Switch:
   a. For zones that have operable windows with indicator switches (at wall or roof), when the window switch(es) indicates the window(s) is(are) open, initiate Unoccupied

mode, ignore Unoccupied Override signals, and reset the zone heating temperature setpoint and the zone cooling temperature setpoints to 40 F and 120 F, respectively.
b. Generate an alarm if the zone temperature is 50 F or less.
c. Revert to normal setpoints when the window switch(es) indicate that window(s) is(are) closed.

3. Unoccupied Mode:
   a. Close terminal unit damper. Ignore signals from space occupancy or carbon dioxide sensors.
   b. If space temperature is greater than unoccupied cooling temperature setpoint, and if central air handling unit is running, modulate damper between no airflow and Maximum Cooling airflow to maintain space temperature at unoccupied cooling temperature setpoint.
   c. If space temperature is less than unoccupied heating temperature setpoint, close damper.
   d. During Unoccupied Mode, if any single zone falls below 40 F, generate an alarm and initiate Setback Mode until all zones are above 50 F.
4. Morning Warm-up or Night Setback Mode
   a. Modulate damper between no airflow and Maximum Heating airflow setpoints, in sequence with modulating heating coil's control valve subject to a maximum discharge air temperature of 95 degrees F (adj.), as appropriate, to maintain space temperature setpoint corresponding to the appropriate mode.
5. Morning Cool-down Mode:
   a. Modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.
6. Night Set-up Mode:
   a. Modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.
7. Night Purge Mode:
   a. Modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.
8. Pre-occupancy Purge Mode:
   a. One hour prior to occupancy operate the terminal unit at a constant airflow rate of 3 air changes per hour for all areas served by the unit and modulate terminal unit damper to maintain corresponding cooling temperature setpoint.
9. Unoccupied Override
   a. When an override signal from a space temperature sensor has been activated, change the mode of the terminal unit to Occupied for 2 hours (adj).
   b. Terminate Unoccupied Override mode when one of the following occurs:
      1) Timed override period of 2 hours (adj) has expired.
      2) Timed override is cancelled.

W. Radiant Floor Heating & Cooling System
1. General:
   a. Maintain slab temperature at corresponding setpoint temperatures at all times, except if the upcoming unoccupied period is longer than 167 hours (adj), at which time lock out chilled water flow and reset slab temperature to 60 F if outdoor air temperature is less than 50 F for 8 continuous hours, or turn off the radiant system if outdoor air temperature exceeds 70 F for 8 continuous hours.
   b. Except as noted for Morning Cooldown mode, at all operating modes, slab temperature shall be not less than 62 degrees F (adj), not more than 80 degrees F (adj), 2 degrees F (adj) warmer than indoor dew point temp, and during unoccupied hours only, 2 degrees F (adj) warmer than outdoor dew point temperature. Generate an alarm if slab temperature is beyond setpoints indicated.

c. Use PID control loops to reset slab setpoint temperature based on current space temperature setpoint and rate of change of space temperature, and upcoming space temperature setpoint (ie change in setpoints corresponding with change of occupancy mode from unoccupied to occupied).
d. Commissioning Agent, TAB Technician shall be present during the commissioning period and provide input for correct setting of PID loop parameters.

2. UNOCCUPIED MODE :
   a. Reset slab temperature setpoint to 70 degrees F (adj) with a deadband of 2 degrees F. Reset space temperature setpoint to set-back temperature. Ignore space CO2 signals, close Terminal Unit damper, and open 6-way valve to heating hot water or chilled water flow, as required to maintain slab temperature setpoint.
3. Morning Warm-Up:
   a. Initiate Morning Warm-up mode using an optimal start algorithm that uses an adaptive learning feature that automatically adjusts the morning warm-up start time so that the average zone temperature in the exterior zones is 68 F (adj) at the start of scheduled occupied period. Reset slab temperature setpoint as determined by PID control loop and open 6-way valve to heating hot water flow, as required to maintain slab space temperature setpoint. Close Terminal Unit damper.
4. Morning Cool Down:
   a. Initiate Morning Cool-down mode using an optimal start algorithm that uses an adaptive learning feature that automatically adjusts the morning cool-down start time so that the average zone temperature in the exterior zones is 72 F (adj) at the start of scheduled occupied period. Reset slab temperature setpoint to 60 F (adj). Open 6-way valve to chilled water flow, as required to maintain slab temperature. Close Terminal Unit damper. At a time period determined by PID loop, lock out chilled water flow so that slab temperature reaches 65 F (adj) 30 minutes (adj) after start of occupancy, at which point chilled water flow lockout is removed.
5. Occupied Mode:
   a. Reset slab temperature setpoint as determined by PID control loop and open 6-way valve to heating hot water or chilled water flow, as required to maintain slab space temperature setpoint.
   b. For spaces with CO2 sensors:
      1) Operate Terminal Unit and set supply air quantity at Minimum Heating CFM and if space CO2 concentration is greater than 800 ppm (adj) modulate damper between Minimum Heating and Maximum Heating airflow setpoints to maintain maximum CO2 concentration of 900 ppm. Generate an alarm if the zone CO2 concentration is greater than 1,000 ppm (adj). Provide adequate delay (time determined during commissioning) to avoid false alarming and adequate time for system to balance during sudden loading of spaces. Modulate Terminal Unit heating hot water control valve to maintain space temperature.
   c. For spaces without CO2 sensors:
      1) Operate Terminal Unit and set supply air quantity at Minimum Heating CFM and modulate Terminal Unit heating hot water control valve to maintain space temperature.
6. Pre-occupancy Purge Mode:
   a. One hour prior to occupancy operate radiant floor system at Morning Warmup or Morning Cool mode, as appropriate. Operate the terminal unit at a minimum flowrate of 3 air changes per hour for all areas served by the unit and modulate terminal unit HHW control valve to maintain heating temperature setpoints.
7. Unoccupied Override:
   a. When an override signal from a space temperature sensor has been activated, change the mode of the radiant zone and the corresponding Terminal Unit(s) to Occupied for 2 hours (adj).
      1) Terminate Unoccupied Override mode when one of the following occurs:

(a) Timed override period of 2 hours (adj) has expired.
(b) Timed override is cancelled.

8. Standby Mode:
   a. During occupied hours, for spaces without an occupancy sensor, enter Standby mode at the end of the Unoccupancy Override period if Unoccupancy Override switch has been activated, or when the Unoccupancy Override switch has been not activated by the occupant.
   b. Initiate Standby mode if all normally occupied spaces served by the unit are provided with occupancy sensors. Enter “Standby Mode” if the occupancy sensors in all rooms served by the terminal unit do not detect occupancy for 15 minutes (adj).
   c. During Standby mode:
      1) Reset cooling temperature setpoint to 3 F (adj) above normal occupied setpoint and heating temperature setpoint to 3 F (adj) below normal occupied heating setpoint.
      2) After 30 minutes in Standby mode (adj), for a period of 15 minutes (adj) reset Minimum Heating CFM of the terminal unit to zero. At the end of 15 minute (adj) period, increase the Minimum outdoor air quantity setpoint of the air handling system by the Minimum Heating CFM of the zone.
      3) If the zone’s occupancy sensors in all rooms served by the terminal unit do not detect occupancy, or Unoccupancy Override switch has not been activated, for an additional 45 minutes (adj), for the next 15 minutes (adj) reset Minimum Heating CFM of the terminal unit to zero. Continue this routine until occupancy is detected, Unoccupancy Override switch has not been activated, or there is a change in the mode of the system.
9. Alarms:
   a. Generate an alarm if dampers or valves are commanded open/closed or to modulate but do not send feedback of proper position. Generate an alarm upon sensing of condensation and lock out cooling water flow at the 6-way valve.

X. Exhaust Fan (Constant Volume)
1. General:
   a. Operate unit under the following modes, as initiated from BMS schedule:
      1) Occupied
         (a) For isolation damper(s) shown on drawings as being connected to the exhaust fan, open isolation damper(s), and run fan continuously.
         (b) Generate an alarm if fan fails to operate.
         (c) Operate supply fan(s) or other units that are indicated as being interlocked with the exhaust fan.
      2) Unoccupied
         (a) Close isolation damper(s), as applicable, and shut down exhaust fan and supply fans or other units indicated as being interlocked with the exhaust fan.
         (b) Operate fan, if called upon by other systems interlocked with the exhaust fan.

Y. Split Type Fan Coil Units
1. Connect with the split unit’s controller, and:
   a. Operate unit as initiated from BAS schedule.
   b. Monitor unit status.
   c. Generate an alarm on receipt of an alarm signal from unit controller.
2. Monitor room temperature and generate an alarm if room temperature is more than 4 F from setpoint (adj).

Z. Variable Refrigerant Flow System

1. Connect to the unit's controller and operate unit as initiated from BAS schedule.
2. Each unit's controller will monitor and control its full range of operations.
3. General:
    a. Unit to operate under the following modes, as initiated from BAS schedule:
        1) Occupied
        2) Unoccupied
4. Occupied Mode:
    a. Fan runs continuously.
    b. Operate fan coil units at occupied mode setpoint temperatures.
5. Create a graphical screen for each Variable Refrigerant Flow system, including all connected fan coils and condensing units, and:
    a. Provide ability of individual or global changes to:
        1) Temperature setpoints.
        2) Fan speed.
        3) Forced shut down of heating and cooling (ie the fan continues operation)
        4) Operation mode setting: cool/heat/fan/dry/auto.
        5) Forced system stop.
    b. Monitor the following additional points in the system's graphical screen:
        1) Unit alarm.
        2) Malfunction code.
        3) Filter alarm.
        4) Thermo-on status (whether the unit is actively heating or cooling).
        5) Compressor status.
        6) Fan status.
        7) Auxiliary heat status.
        8) Communication status.
        9) Remote controller prohibit status.

AA. Meters
1. Meters:
    a. Connect to water and electricity meters, as supplied and installed by other Divisions or Sections, at incoming water and electricity services and monitor and trend all values.
    b. Refer to drawings for quantity and location of meters.
    c. Display summed meter data for the last year, month, week, and day, and allow the operator to download all saved data in CVS or equivalent ASC-II format.
    d. For electricity meter(s) trend, store and display data for power demand, cumulative KWH consumption, KVAR, Amps, and volts. Display monthly, weekly daily, and instantaneous usage and PV system's KWH production, where applicable.
    e. For electricity meter(s) trend, store and display instantaneous consumption in 1 minute interval as well as monthly, weekly and daily usage.

AB. Variable Frequency Drives (VFD):
1. Monitor variable speed drives from points indicated on Control Diagrams and through LAN communications port on each drive. As minimum, monitor and/or report the following points:
    a. Frequency output - Hz
    b. Speed - Hz
    c. Current - Amps
    d. Power - KW
    e. Energy - KWH
    f. Runtime - Hours
    g. System Fault

h. Input speed setpoint - Hz (reporting in " percent" speed is not acceptable)

2. Generate an alarm if VFD status is lost for more than 1 minute, VFD fault, drive failure, is off, or in hand.

AC. Combination Fire Smoke Dampers (FSD):

1. Close dampers 60 seconds (adj) after their corresponding fan system is no longer operating.
2. Open dampers when fan systems are operating.

END OF SECTION

SECTION 23 2116

HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included:
1. Diaphragm Type Expansion Tanks
2. Air Vents
3. Centrifugal Air Separator
4. Pressure Reducing Valves
5. Liquid Flow Switches
6. Instrument Probe Fittings
7. Strainers
8. Suction Diffusers
9. Relief Valves

1.2 RELATED SECTIONS

A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

A. References and Standards as required by Section 23 0000, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, meet the following:
1. ASME (BPV VIII, 1) - Boiler and Pressure Vessel Code, Section VIII, Division 01 - Rules for Construction of Pressure Vessels; The American Society of Mechanical Engineers.

1.4 SUBMITTALS

A. Submittals as required by Section 23 0000, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, provide:
1. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.
2. Certificates: Inspection certificates for pressure vessels from Authority Having Jurisdiction (AHJ).
3. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
4. Project Record Documents: Record actual locations of flow controls.
    a. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.5 QUALITY ASSURANCE

A. Quality assurance as required by Section 23 0000, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, meet the following:
   1. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this Section, with minimum three years of documented experience.

1.6 WARRANTY

A. Warranty of materials and workmanship as required by Section 23 0000, HVAC Basic Requirements and Division 01, General Requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

B. Provide temporary protective coating on cast iron and steel valves.

C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Diaphragm Type Expansion Tanks:
   1. Amtrol Inc.
   2. ITT Bell & Gossett
   3. Taco, Inc.
   4. Armstrong
   5. Wessels
   6. Aurora
   7. Or approved equivalent.

B. Air Vents:
   1. Armstrong International, Inc.
   2. ITT Bell & Gossett.
   3. Taco, Inc.
   4. Hoffman
   5. Amtrol
   6. Metraflex
   7. Or approved equivalent.

C. Centrifugal Air Separator:
   1. Armstrong
   2. ITT Bell and Gossett
   3. Taco, Inc.

4. Amtrol
5. Wheatly
6. Aurora
7. Or approved equivalent.

D. Pressure Reducing Valves:
1. Armstrong
2. ITT Bell and Gossett
3. Taco, Inc.
4. Amtrol
5. Kunkle
6. Or approved equivalent.

E. Liquid Flow Switches:
1. McDonnell & Miller
2. Dwyer
3. Or approved equivalent.

F. Instrument Probe Fittings:
1. Pete's Plug
2. Or approved equivalent.

G. Strainers:
1. Armstrong International
2. Mueller
3. Keckley
4. Hoffman
5. Wheatly
6. Or approved equivalent.

H. Suction Diffusers:
1. ITT Bell & Gossett
2. Armstrong
3. Taco
4. Amtrol
5. Wheatly
6. Mueller
7. Or approved equivalent.

I. Relief Valves:
1. Armstrong
2. ITT Bell & Gossett
3. Taco
4. Amtrol
5. Kunkle
6. Or approved equivalent.

2.2 DIAPHRAGM-TYPE EXPANSION TANKS

A. Construction: Welded steel, tested and stamped in accordance with ASME (BPV VIII, 1); supplied with National Board Form U-1, rated for working pressure of 125 PSI, with flexible EPDM diaphragm sealed into tank, and steel support stand.

B. Accessories: Pressure gauge and air-charging fitting, tank drain.

2.3 AIR VENTS

A. Manual Type: Short vertical sections of pipe to form air chamber, with 1/8-inch brass needle valve at top of chamber.

B. Automatic Float Type:Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.

2.4 CENTRIFUGAL AIR SEPARATOR

A. Description: Fabricated steel tank stamped in accordance with Section VIII of ASME Boiler and Pressure Vessel Code for Unfired Vessels, stamped for 150 PSI, with tangential inlet and outlet connections, internal perforated stainless steel air collector tube and blowdown connection. Provide steel support stand.

2.5 PRESSURE REDUCING VALVES

A. Brass body, adjustable range, inlet check valves, removable inlet strainer, noncorrosive valve seat and stem, 3/4-inch size unless otherwise shown, factory set at fill pressure as indicated on drawings.

2.6 LIQUID FLOW SWITCHES

A. Description: Brass for wetted parts with packless construction, paddle with removable segments for pipe size and flow velocity, vapor proof electrical compartment for switches mounted on cold hydronic piping systems, switches for 115V, 60 Hz, 1-phase with 7.4A rating.

2.7 INSTRUMENT PROBE FITTINGS

A. Brass or stainless steel body and cap, high pressure rated, valve material neoprene, Nordal or Viton to suit temperature range, 1/4-inch or 1/2-inch NPT tailpiece.

2.8 STRAINERS

A. Size 2-inches and Under: Screwed brass or iron body for 175 PSI working pressure, Y pattern with 1/16-inch stainless steel perforated screen.

B. Size 2-1/2-inches and Larger: Flanged or grooved and above: iron body for 175 PSI working pressure, Y pattern with 1/16 stainless steel perforated screen.

C. Basket Pattern: Flanged iron body for 175 PSI working pressure, basket pattern with 1/8-inch stainless steel perforated screen, clamped or bolted cover.

2.9 SUCTION DIFFUSERS

A. Fitting: Angle pattern, cast-iron body, threaded for 2-inch and smaller, flanged for 2-1/2-inch and larger, rated for 175 PSI working pressure, with inlet vanes, cylinder strainer with 3/16-inch

diameter openings, disposable fine mesh strainer to fit over cylinder strainer, and permanent magnet located in flow stream and removable for cleaning, adjustable support foot.

2.10 RELIEF VALVES

A. Size and capacity as selected by installer for proper relieving capacity, in accordance with ASME Boiler and Pressure Vessel Code.

B. Combined Pressure-Temperature Relief Valves: Bronze body, test lever, thermostat, complying with ANSI Z21.22 listing requirements for temperature discharge capacity. Provide temperature relief at 210F, and pressure relief at 125 PSI.

C. Pressure Relief Valves: Bronze body, test lever, ASME rated. Provide pressure relief as indicated on drawings.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Install specialties in accordance with manufacturer's instructions.

B. Support pump fittings with floor mounted pipe and flange supports. Provide vibration isolation, same as pump, to avoid short circuiting.

3.2 DIAPHRAGM TYPE EXPANSION TANKS

A. Install tank in accordance with manufacturer's instructions. Charge tank with air per manufacturer's instructions. Prior to making connection from the tank to the system, check the air charge. Valve is to be opened to the system when it is determined that the air pressure is equal to the minimum system pressure at the tank location.

3.3 AIR VENTS

A. Where large air quantities can accumulate, provide enlarged air collection standpipes.

B. Automatic: Furnish and install automatic air vents in mechanical equipment rooms and outdoors only. Install at high points of system piping, at heat transfer coils, and elsewhere as required for system air venting. Vents: 3/4-inch with 1/2-inch IPS drain piping to the nearest floor drain or other approved location. Provide a ball valve and union ahead of all automatic air vents. Do not install above ceilings or locations where discharge may occur and cause damage.

C. Manual Vents: Provide at high points of system piping, at heat transfer coils, and elsewhere as required for system venting where automatic air vents are not to be installed. Provide 10-inch length of 1/4-inch copper tube with 180 degree bend down to discharge into hand-held bucket.

3.4 CENTRIFUGAL AIR SEPARATOR

A. Install in pump suction lines and as indicated. Run piping to expansion tank with 1/4-inch per foot (2 percent) upward slope towards tank. Install drain valve on units 2-inches and over.

3.5 PRESSURE REDUCING VALVES

A. Install as indicated, and in accordance with manufacturer's instructions with three valve bypass.

3.6 LIQUID FLOW SWITCHES

A. Install on inlet to water chiller as indicated. Install in horizontal pipe with switch mounted in tee on top of pipe with minimum of 24 inches of straight pipe with no fitting both upstream and downstream of switch. Remove segments of paddle to fit in accordance with manufacturer's instructions.

3.7 INSTRUMENT PROBE FITTINGS

A. Test Plugs: Install where indicated and in accordance with the manufacturer's recommendations.

3.8 STRAINERS

A. Provide valved drain and hose connection on strainer blow down connection.

3.9 SUCTION DIFFUSERS

A. Provide pump suction diffuser on suction side of base mounted centrifugal pumps where indicated. Remove temporary strainers after cleaning systems.

3.10 RELIEF VALVES

A. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.

B. Pipe relief valve outlet to nearest floor drain.

C. Where one line vents several relief valves, make cross-sectional area equal to sum of individual vent areas.

D. Water Relief Valves: Install as indicated, and on expansion tanks, hot water tanks and pressure vessels. Pipe discharge to floor drain. Comply with ASME Boiler and Pressure Vessel Code.

END OF SECTION

SECTION 23 6400

HEAT RECOVERY HEAT PUMP

PART 1 - GENERAL

1.1 SUMMARY

A. Work included:
   1. Heat Recovery Heat Pump

1.2 RELATED SECTIONS

A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

A. References and Standards per Section 23 0000, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, meet the following:
   1. Efficiency and capacity performance data to be certified per current version of AHRI Standard 550/590.
   2. Acoustic sound performance data to be rated in accordance with current versio of AHRI STandard 370/575.
   3. Comply with Standards ANSI/ASHRAE 15 and ASME Section VIII.
   4. Electrical components except for motor to be listed and labeled by UL. Assemblies to be constructed in accordance with UL-465.
   5. IEC EN 60335-2-40 (Safety standard regarding electrical heat pumps, air conditioners, and dehumidifiers);
   6. IEC EN 61000-6-1 and IEC EN 61000-6-3 (Electromagnetic emissions and immunity levels for residential environments);
   7. IEC EN 61000-6-2 and IEC EN 61000-6-4 (Electromagnetic emissions and immunity levels for industrial environments);
   8. EN378 (Refrigerating system and heat pumps - safety and environmental requirements);
   9. UNI EN 12735 (Seamless, round copper tubes for air conditioning and refrigeration);
   10. UNI EN 14276 (Pressure equipment for cooling systems and heat pumps).
   11. It thus complies with the essential requirements of the following directives:
      a. LVD Directive: 2006/95/EC
      b. Electromagnetic Compatibility Directive 2004/108/EC
      c. Machinery Directive 2006/42/EC
      d. Pressure Equipment Directive 97/23/EC
      e. In accordance with Directive 97/23/EC, meet the Quality Assurance Procedure (Form H) with certificate No.06/270-QT3664 Rev.5 issued by notified body n.1131: CEC, via Pisacane 46, Legnano (Milano), Italy.

1.4 SUBMITTALS

A. Submittals as required by Section 23 0000, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, provide:
   1. Product Data: Provide rated capacities, weights, specialties and accessories refrigerant, electrical requirements and wiring diagrams.
   2. Shop Drawings: Indicate components, assembly, dimensions, weights and loadings, mounting and anchorage, required clearances, and location and size of field connections. Indicate equipment, piping and connections, valves, strainers, and thermostatic valves required for complete system.
   3. Provide part load operating characteristics and application part load value calculation (NPLV) in accordance with AHRI Standard 550/590 Certified Reports for:
      a. EER Full Load and IPLV @ standard AHRI conditions.
      b. EER Full Load and NPLV @ design conditions.
      c. A-weighted sound level. Individual frequency range data to be db, not A-weighted. Note if data is sound pressure or sound power.
      d. Fluid pressure drops in feet head.
      e. Refrigerant type & volume in pounds per circuit.
      f. Fouling Factor (AHRI defaults unless noted otherwise)
      g. Elevation
      h. Percent & Type Glycol
      i. COP at heating only.
      j. COP simultaneous heating and cooling.
   4. Manufacturer's Instructions: Submit manufacturer's complete installation instructions.

1.5 QUALITY ASSURANCE

A. Quality assurance as required by Section 23 0000, HVAC Basic Requirements and Division 01, General Requirements.

1.6 WARRANTY

A. Warranty of materials and workmanship as required by Section 23 0000, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, provide:
   1. Minimum 1 year parts, materials and labor and 5 year compressor parts-only warranty.

1.7 COORDINATION

A. Coordinate size and location of concrete bases including but not limited to sufficient base footprint to allow proper anchorage and anchor-bolt inserts.

B. Coordinate installation of roof curbs and penetrations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Heat Recovery Heat Pump:
   1. Multistack
   2. Aermec

B. Approved Alternate Manufacturer: Drawings indicate Basis of Design manufacturer, alternate acceptable manufacturers listed may be provided, meeting capacities of Basis of Design system. Each alternate manufacturer has a specific method of freeze protection that may require glycol system that is proprietary. Therefore, alternate proposed systems are to include the cost of supplement equipment (including but not limited to glycol tank, feed systems, pumps, piping, valves etc.), equipment location modification, electrical modifications, architectural modifications, structural modifications, maintenance and access modifications, and other modifications required to submit the manufacturer that is not the Basis of Design.

2.2 HEAT RECOVERY HEAT PUMP

A. Description:
1. Factory assembled packaged air-cooled heat recovery heat pump consisting of compressors, condensers, evaporator, lubrication system, refrigerant piping and specialties, wiring and operating and safety controls including motor starter and control center, contained on common frame. Unit fully charged with refrigerant at factory. Designed for continuous simultaneous heating/cooling hydronic distribution. Electric sump anti-freeze system.
2. Electrical components mounted in rain-tight, weatherproof enclosure.
3. UL listed and labeled.
4. Units to have Energy Efficiency Rating (EER)/Coefficient of Performance (COP) as indicated on drawings and not less than prescribed by ASHRAE Standard 90.1 or local energy codes. Performance certified per ARI 550-88 and based on 0.00010 fouling factors for evaporator.

B. Compressor: Direct drive, hermetic scroll compressors; positive displacement oil pump; suction and discharge service valve; internal muffler; crankcase heater; suction strainer; oil strainer; oil sight glass; and oil charging connection. Minimum of two circuits.

C. Motor: Continuous duty induction type, suction gas cooled and suitable for voltage fluctuation of plus or minus 10 percent of nameplate voltage. Provide solid-state thermal overload sensors in each motor winding and external overload protection on all three phases.

D. Evaporator: Plate-to-plate type heat exchanger consisting of parallel stainless steel plates brazed with copper braze material. Units tested and stamped in accordance with ASME Code for Unfired Pressure Vessels for refrigerant side working pressure of 225 PSIG and waterside working pressure of 150 PSIG. Provide water manifold package for supply and return water connections and water strainer on supply with blow down valve.

E. Air-Cooled Condensers: Unit circuited to provide subcooling. Condensers constructed of seamless copper tubes with mechanically bonded aluminum fins, leak tested at 150 PSIG, pressure tested at 450 PSIG. Can operate as condenser or evaporator.

F. Condenser Fans and Motors: Provide direct-drive, helical type condenser fans, with steel wire safety guards and 3-phase, permanently lubricated and inherently protected Totally Enclosed Air-Over (TEAO) motors with corrosion resistant fan shaft. Rotors statically and dynamically balanced.

G. Head Pressure Control: Provide head pressure control system by varying speed of condenser fans on each refrigeration circuit based to permit operation to 0 degrees F outdoor ambient temperature.

H. Refrigerant Circuit Accessories: Provide required refrigeration accessories including condenser liquid line valves, combination filter-dryers, solenoid liquid stop valves, liquid line sight glasses, expansion valves and isolation valves adequate to allow isolation and servicing of compressors, receivers, accumulators, reversing valve, compressor intake liquid seperator, and evaporators.

I. Insulation: Factory insulate evaporator including heads and cold refrigerant piping, with 1-inch expanded polyvinyl chloride (K = 0.28) over evaporator to protect against freezing. Provide heat tape over evaporator to protect from freezing at ambient air temperatures to -20 degrees F.

J. Wiring: Field wiring to consist of single point electrical connection to heat pump and 115V control interlock wiring to pumps and flow switches. Provide terminals.

K. Flow Switches: Provide flow switches in mains for positive determination of water flow.

L. Thermostatic Valve: Standard mechanical thermostatic valve with outdoor equalizer placed at the exit of the evaporator, and bulb sensitive to the intake temperature. Depending on the heat load, it modulates the gas flow, while maintaining the correct degree of superheat of the intake gas to the compressor. This makes it possible to work with a minimum temperature of the produced water at 4 degrees C.

M. Control Panel: Unit equipped with control panel utilizing 120-volt, single phase power supply from transformer in starter and containing following microprocessor based accessories and features:
   1. Display of evaporator/condenser refrigerant pressures, oil pressure, return/leaving chilled water temperature, evaporator/condenser refrigerant temperatures, compressor discharge temperature, oil temperature, saturation temperature in evaporator and condenser, compressor run status (elapsed time meter).
   2. Provide programming of setpoints through keypad and include leaving water temperature, percent current demand, and remote reset temperature range.
      a. Provide provisions for chilled water reset based on return-water or outside air space temperature.
   3. Safety controls annunciated through alpha-numeric display and include high/low oil pressure, high/low refrigerant pressure, low/high water temperature, starter faults, low flow through evaporator, high oil temperature, high compressor discharge temperature, high motor temperature high current.
   4. Choice of control modes from hand/off/auto.
   5. Extra contact to annunciate machine failure to remote area and extra contact for safety shutdown from external source.
   6. Pilot relays to start pumps.
   7. Time limit control to limit starts to one in 30 minutes or as recommended by manufacturer.
   8. Communications to BAS to consist of BACnet communications protocol. Coordinate with Section 23 0900, Instrumentation and Control Performance Specifications. Provide separate interface signal for BAS communications port to monitor and control following:
      a. Entering and leaving water temperature
      b. Water set point
      c. Current limit set point
      d. Runtime - Hours
      e. System Fault
      f. On/off Control Signal
   9. Master Controller shall be capable of monitoring the START/STOP operation of the unit to aid in determining the water temperature inside the heat exchanger. Controller software shall have logic to modulate valve position in an individual module. Controller shall have alarms for Low Water temperature and be capable of

operating the system primary and secondary pumps. See Section 230900 for sequence of operation regarding Heat Pump freeze protection.

N. Capacity Control: Electronic thermostat and controller to modulate capacity of machine to maintain constant (plus or minus 0.5 degree F) water supply temperature using proportional-integral control. Water temperature setpoint to be remotely adjustable from building control system. Coordinate requirements with 23 09 00, Instrumentation and Control Performance Specifications. Machine modulates to within 20 percent capacity without using hot gas bypass per ARI 550 requirements.

O. Starter:
1. Provide unit mounted starter cabinet with combination starter, and circuit breakers.
2. Provide protection devices including 3 leg overload protection high temperature safety protection with indicating light and reset button, over and under voltage protection.
3. Provide indicator lights on starter panel including control power on, chiller start, chiller run, overload current.

P. Refrigerants: Chillers using HFC-410A are acceptable. Chillers using other refrigerants are not acceptable unless prior approval received.

Q. Probes and Transducers: Input and output water temperature probes, high pressure transducers (one per circuit), and low pressure transducers (one per circuit).

R. Accessories:
1. BACNet-IP interface to a building management system.
2. Protection grid protecting the outdoor coil from accidental impacts, and preventing access to the underlying area where the compressors and the circuit are located.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions. Maintain manufacturer's recommended clearances for service and maintenance.

B. Provide connection to electrical service.

C. Provide connection of electrical wiring between starter and chiller control panel, oil pump, and purge unit. Provide wiring between flow switches and control panel.

D. Install units on seismic spring vibration isolation system.

E. Provide seismic restraints in accordance with Division 23, HVAC Sections.

F. Provide evaporator connections to water piping. Provide additional accessories as shown on details, schedule, and piping diagrams. (Additional requirements may be shown on Drawings).

G. Insulate evaporator and cold surfaces.

H. Arrange piping for easy dismantling to permit tube cleaning and to permit for removal of heat pump.

I. Install separate devices furnished by manufacturer.

3.2 STARTING EQUIPMENT AND SYSTEMS

A. Engage factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gauges are installed.
4. Operate unit(s) for run-in period according to manufacturer's written instructions.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief is vented outside.
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during unit(s) startup and shutdown.
9. Verify and record performance of water flow and low/high-temperature interlocks.
10. Verify and record performance of protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Prepare written startup report that records results of tests and inspections.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose.

F. Supply initial charge of refrigerant and oil.

G. Demonstrate system operation and verify specified performance.

END OF SECTION

SKETCHES

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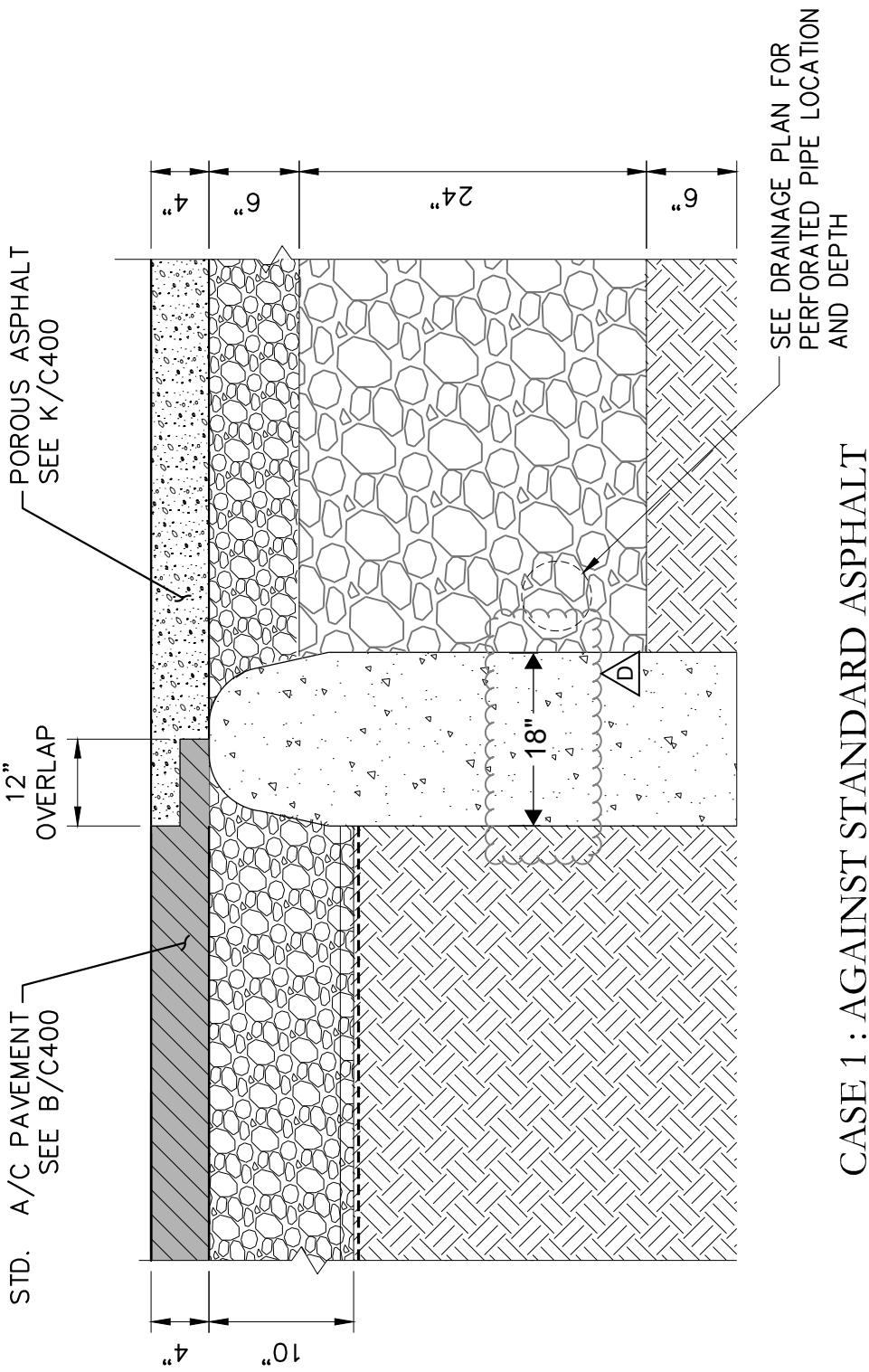

CASE 1 : AGAINST STANDARD ASPHALT

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PROJECT: ATHERTON CIVIC CENTER
PROJECT NO: TofA 54015 WRNS 15007.00
TITLE: POROUS ASPHALT EDGE COND.
CASE1: AGAINST STD. ASPHALT

SCALE: NTS
BY: TH
ISSUES/REV.: ADDENDUM 3

CSK-001

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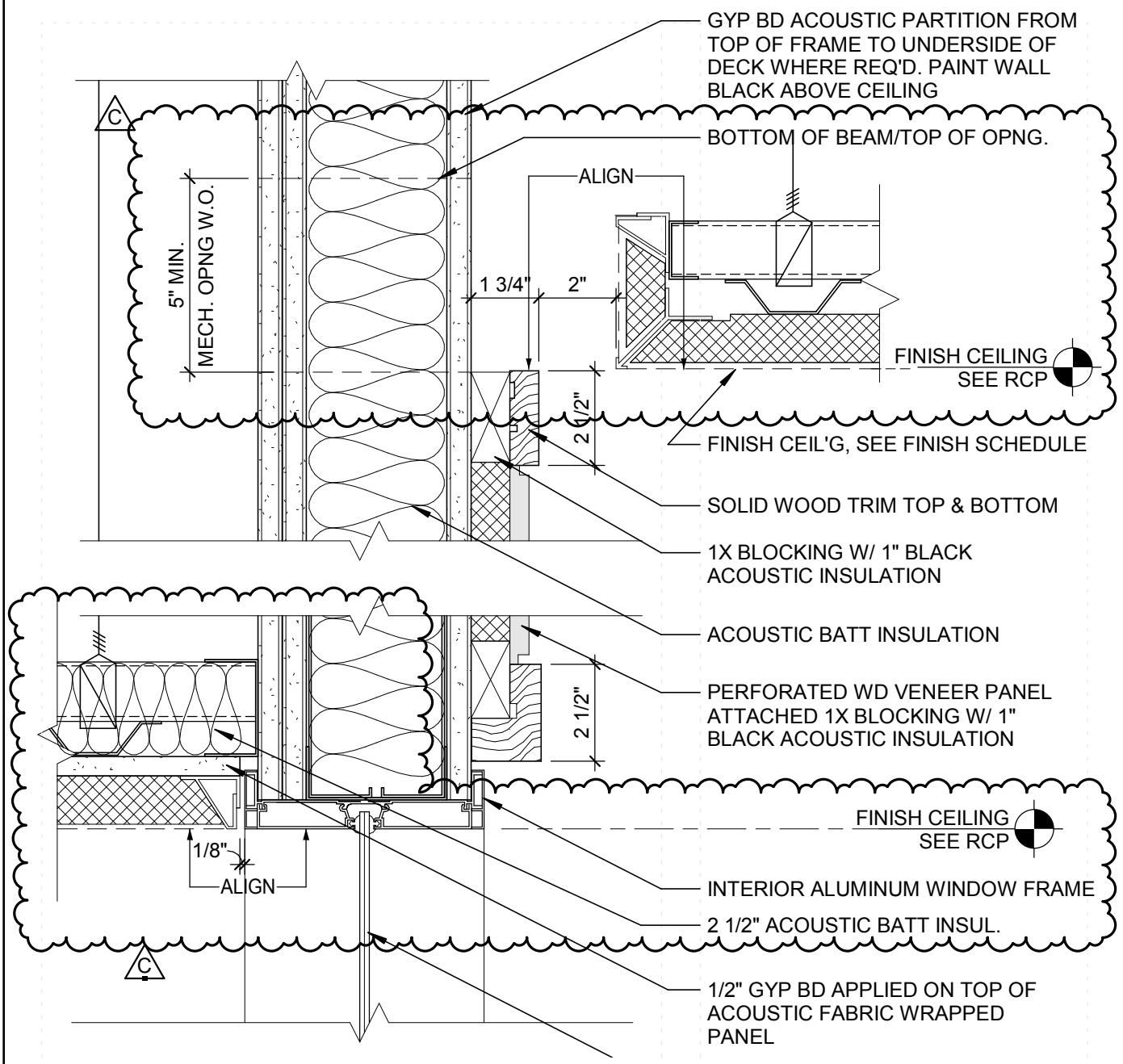

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PROJECT: ATHERTON CIVIC CENTER
PROJECT NO: TofA 54015 WRNS 15007.00
TITLE: LIBRARY INT. GLAZED PARTITION

SCALE: 3" = 1'-0"
BY: EFO
ISSUES/REV.: ADDENDUM 3

ASK-008