BID # WMC24-02 **ADDENDUM NUMBER 04**

REQUEST FOR BIDS FOR:

Berlin MEP Upgrades
at White Mountains Community College
2020 Riverside Drive, Berlin NH 03570
A component of the Community College System of New Hampshire
26 College Drive, Concord, NH 03301
September 5, 2024

TO: ALL CONTRACT BIDDERS OF RECORD

This Addendum forms a part of the Contract Documents and modifies the Request for Bids dated August 5, 2024, with amendments and additions noted below. This Addendum consists of a total of Forty (40) pages.

CLARIFICATIONS TO THE REQUEST FOR PROPOSAL:

BID DATE: Remains the same as in Addendum 3 – September 12th, 2024 at 2pm.

Revised Scope of Services:

1. Remove prior Section 230900 and replace with the attached Section 230900 for Addendum 4.

Acknowledge receipt of this Addendum with the Proposal Form. Failure to do so may disqualify the Bidder.

NOTE: IN THE EVENT THAT YOUR BID HAS BEEN SENT TO THIS OFFICE PRIOR TO RECEIVING THIS ADDENDUM, RETURN THE ADDENDUM WITHIN THE SPECIFIED TIME WITH ANY CHANGES YOU MAY WISH TO MAKE AND MARK ON THE REMITTANCE ENVELOPE BID INVITATION NUMBER AND OPENING DATE. RETURNED ADDENDA WILL SUPERSEDE PREVIOUSLY SUBMITTED BID.

Bidder_____

By_____Date_____
(This Document Must Be Signed)

Name_____
(Please Print or Type Name)

Matthew Moore, P.E.
Director of Capitol Planning & Development
Community College System of New Hampshire
26 College Drive, Concord, N.H. 0330

SECTION 230900 – INSTRUMENTATION AND CONTROL FOR MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Direct Digital Control (DDC) equipment.

B. Software.

C. Installation.

D. Mechanical Commissioning.

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Piping:
1. Control Valves – piping connections.
2. Temperature Sensor Wells and Sockets.
3. Pressure Sensors and Switches.
4. Flow Switches.
5. Flow Meters.

B. Ductwork:
1. Access Doors.
2. Airflow Measuring Stations.
3. Dampers - ductwork connections.

1.3 PRODUCTS FURNISHED UNDER OTHER SECTIONS

A. Controllers furnished with some Plumbing equipment (Division 22).

B. Controllers furnished with some HVAC equipment (Division 23).

C. Monitoring devices furnished with some Electrical equipment (Division 26).

1.4 RELATED SECTIONS

A. Division 01 Section “General Commissioning Requirements.”

B. Division 01 Section “Testing, Adjusting, and Balancing for HVAC.”

C. Division 08 Section “Access Doors and Frames.”

D. Division 23 Section “Common Work Results for HVAC.”

E. Division 23 Section “Common Motor Requirements for HVAC Equipment.”

1.5 REFERENCES

A. U.S. Department of Justice – 2010 ADA Standards for Accessible Design.

B. ASME MC85.1 - Terminology for Automatic Control.

C. NEMA EMC1 - Energy Management Systems Definitions.

D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

E. NFPA 70 - National Electrical Code.

F. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

1.6 SYSTEM DESCRIPTION

A. A fully integrated Automatic Temperature Control (ATC) Building Management and Control System incorporating Direct Digital Control (DDC), energy management, equipment monitoring, and control consisting of the following:
   1. Microcomputer-based equipment controllers interfacing directly with sensors, actuators and environmental delivery systems.
   2. Electric controls and mechanical devices for items indicated on Drawings and described hereinafter including dampers, valves, and motor drives.
   3. Microcomputer-based terminal controllers interfacing with sensors, actuators, and terminal equipment control devices.

B. Submittals, data entry, electrical installation, programming, start up, test and validation, instruction of Owner's representative on maintenance and operation, as built documentation, and system warranty.

C. System Summary:
   1. The intent of this project is to provide an ATC system with electric actuators.
   2. For existing pneumatically controlled equipment which is to remain and which requires temporary removal, modifications or relocation, provide pneumatic tubing and associated controls as required to return equipment to its original operating conditions.
   3. Items which according to the Sequence of Operations are designated to be controlled by a thermostat, such as Cabinet unit heaters, unit heaters, terminal heating units, and the like, shall be viewable at the DDC system, but are not required to have the ability to modify setpoints via remote access to the DDC system. At the Contractor’s option, they may have full DDC control.
   4. Makeup air units, rooftop HVAC units, and terminal heating units which are designated to be controlled by a temperature sensor shall be interfaced with the DDC system, such that monitoring and setpoint adjustment shall be accomplished through the graphical user interface at the operator workstation.

D. Note: The terms “BMS”, “ATC”, and “DDC” are used somewhat interchangeably throughout this Section.

1.7 DEFINITIONS

A. Note: The terms ATC, BAS, and DDC may be used interchangeably in this Section and on the

Drawings, to indicate the overall control system.

B. Definitions:
1. ATC: Automatic temperature control.
2. BACnet: A control network technology platform for designing and implementing interoperable control devices and networks.
3. BAS: Building Automation System.
4. DDC: Direct digital control.
5. I/O: Input/output.
6. MS/TP: Master slave/token passing.
7. PC: Personal computer.
8. PID: Proportional plus integral plus derivative.
9. RTD: Resistance temperature detector.

1.8 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:
1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds.
6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
a. Water Temperature: Plus or minus 1 deg F (0.5 deg C).
b. Water Flow: Plus or minus 5 percent of full scale.
c. Water Pressure: Plus or minus 2 percent of full scale.
d. Space Temperature: Plus or minus 1 deg F (0.5 deg C).
e. Ducted Air Temperature: Plus or minus 1 deg F (0.5 deg C).
f. Outside Air Temperature: Plus or minus 2 deg F (1.0 deg C).
g. Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C).
h. Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C).
i. Relative Humidity: Plus or minus 5 percent.
j. Electrical: Plus or minus 5 percent of reading.

1.9 SUBMITTALS

A. Submit in accordance with Division 01 Section “Submittal Procedures.”

B. Qualification Data: For Installer and manufacturer.

C. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for

materials, and installation and startup instructions for each type of product indicated.

1. Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
2. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

D. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including size and flow characteristics.
8. DDC System Hardware:
   a. Wiring diagrams for control units with termination numbers.
   b. Schematic diagrams and floor plans for field sensors and control hardware.
   c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control units.
9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
10. Controlled Systems:
    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.

E. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with the open protocol standard compatible with the Owner's existing Delta system, ASHRAE Standard 135 (BACnet).

F. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or CD, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens. Sample graphic screens are included in Appendix A of this specification section. Graphics must match the sample graphics screens to the greatest extent possible.

G. Field quality-control test reports.

H. Operation and Maintenance Data.

1.10 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Division 01 Section "Operation and Maintenance Data."

B. For mechanical instrumentation and control system to include in emergency, operation, and maintenance manuals.

C. In addition to items specified in Division 01, include the following:
   1. Maintenance instructions and lists of spare parts for each type of control device.
   2. Exploded assembly views.
   3. Interconnection wiring diagrams with identified and numbered system components and devices.
   4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
   5. Calibration records and list of set points.

D. Manuals: Provide the following:
   1. An Operator's Manual with graphic explanations of keyboard use for operator functions specified under Operator Training.
   2. Computerized printouts of equipment controller’s data file construction including point processing assignments, physical terminal relationships, scales and offsets, command and alarm limits, and others as applicable.
   3. A manual including revised as-built documents of materials required under the paragraph "SUBMITTALS" in this Specification Section.
   4. Provide the quantity of manuals specified in Division 01, and at least 2 Operator’s Manuals and 2 As-Built Manuals to the Owner. Refer to other Sections of the Specifications for project requirements for quantities of documentation.

1.11 CODES AND APPROVALS

A. The complete temperature control installation shall be in strict accordance to the national and local electrical codes and the electrical Division of these Specifications. Devices designed for or used in line voltage applications shall be UL listed. Microprocessor based remote and central devices shall be UL916 Listed.

B. Electronic equipment shall conform to the requirements of FCC regulation Part 15, Section 15 governing radio frequency electromagnetic interference and be so labeled.

1.12 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with ASHRAE Standard 135 (BACnet) for DDC system components.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Division 01 Section “Project Requirements.”

B. Factory-Mounted Components: Where control devices specified in this Section are indicated

to be factory mounted on equipment, provide shipping of control devices to equipment manufacturer, in a timely manner coordinated with the equipment manufacturer.

C. Components to be Installed under Other Sections: For components to be installed under other Sections of the Specifications, provide delivery of components to appropriate Subcontractors, provide installation instructions, and supervise their installation.

1.14 COORDINATION

A. Coordinate location of thermostats and other exposed control sensors with Contract Drawings before installation.

B. Coordinate equipment with Division 26 and existing fire alarm system to achieve compatibility with equipment that interfaces with that system.

C. Coordinate line-voltage power supplies with Division 26.

1.15 WARRANTY

A. Components, system software, parts, and assemblies furnished under this Section shall be guaranteed against defects in materials and workmanship for 1 year from acceptance date.

B. Labor to troubleshoot, repair, reprogram, or replace system components shall be provided at no charge to the Owner during the warranty period.

C. Corrective software modifications made during warranty service periods shall be updated on user documentation and on user and manufacturer archived software disks.

PART 2 - PRODUCTS

2.1 ACCEPTABLE SUPPLIERS

A. Acceptable Manufacturers and Installers:
1. Automated Logic Corp., WebCTRL Series, installed by Trident Controls Inc., 187 Gray Road, Unit A, Cumberland, ME 04021.
2. Honeywell Controls, installed by Honeywell Inc., 501 County Road, Westbrook, ME 04092.
3. Honeywell Controls, installed by Honeywell Inc., 70 Wells Ave., Newton Highlands, MA 02459.
4. Honeywell Controls, installed by Honeywell Inc., 500 Narragansett Pk. Dr., Pawtucket, RI 02861.
5. Honeywell Controls, installed by Honeywell Inc., 30 Cold Spring Rd., Rocky Hill, CT 06033.
6. Siemens, Staefa Control Systems, Talon Series, installed by Siemens Building Technologies, Inc., 66 Mussey Road, Scarborough, ME 04074.
7. Siemens, Staefa Control Systems, Talon Series, installed by Siemens Building Technologies, Inc., 11 Court St., Exeter, NH 03833.
8. TAC, I/A Series, installed by Maine Controls, 400 Presumpscot Street, Portland, ME 04103.
9. TAC, I/A Series, installed by Control Technologies, New Hampshire Office, 70 Zachary

Road, Manchester, NH 03109.

10. TAC, I/A Series, installed by Control Technologies, Massachusetts Office, 500 West Cummings Park, Suite 1050, Woburn, MA 01801.
11. TAC, I/A Series, installed by Control Technologies, New York Office, 3500 Sunrise Highway, Suite T209, Great River, NY 11739.
12. TAC, I/A Series, installed by Control Technologies, Vermont Office, 121 Park Avenue, Suite 10, Williston, VT 05495.
13. Tridium Niagara N4, installed by Alliance Group Services, Vermont Office, 6 David Drive, Essex Junction, VT 05452.
14. Johnson Controls, installed by Johnson Controls Inc., 500 Harvey Road, Manchester, NH 03103.
15. Johnson Controls, installed by Trident Controls Inc., 187 Gray Road, Unit A, Cumberland, ME 04021.
16. TAC, I/A Series, installed by Basix Automation Integrators, 10 Crosby Rd, Dover, NH 03820.
17. TAC, I/A Series, installed by Basix Automation Integrators, 89 Ethan Allen Drive Unit C, South Burlington, VT 05453.
18. No Substitutions.

B. The Temperature Control Contractor (or Subcontractor) shall hereinafter be referred to as the ATC Contractor.

2.2 SYSTEM REQUIREMENT

A. Provide complete direct digital and electronic control system consisting of temperature sensors, thermostats, control valves, dampers, operators, indicating devices, interface equipment, and other apparatus required to operate mechanical system and to perform functions specified. Provide controls for the following:

1. Air conditioning systems.
2. Boilers, furnaces, and fuel-fired equipment.
3. Control dampers and valves.
4. Cooling and heating terminal units.
5. Exhaust, return, and supply fans.
6. Filter pressure drops.
7. Heat pump systems.
8. Electrical demand management.
9. Electrical system monitoring.
10. Fire alarm system interfaces.
11. Lighting control system interfaces.
12. Graphical workstation.
13. Provide hardware and software required for remote monitoring of the ATC system through modem or ethernet interface. Remote monitoring must tie into the school-system-wide interface and must match existing graphics and capabilities for other campuses that are part of the school-system-wide interface.

2.3 DATA INPUTS AND OUTPUTS

A. Input/output sensors and devices shall be closely matched to the requirements of the remote panel for accurate, responsive, noise-free signal input/output. Control input response shall be

high-sensitivity and matched to the loop gain requirements for precise and responsive control.

B. Duct temperature sensors shall be rigid stem or averaging type as required. Provide water sensors with a separable copper, monel or stainless-steel well.

C. Control relays and analog output transducers shall be compatible with equipment controllers output signals. Relays shall be suitable for the loads encountered. Analog output transducers shall be designed for precision closed loop control with pneumatic repeatability error no greater than 1/2 percent.

D. Data inputs and outputs shall be compatible with variable frequency drives; see Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.4 TEMPERATURE CONTROL CENTRAL HARDWARE

A. Operator Workstations: Operator workstation shall meet the following minimum criteria:
1. Operator workstation shall be Acer, Dell, Hewlett Packard, or IBM/Lenovo. No substitutions.
2. Form Factor: Tower.
3. Operating System: MS Windows 10 Professional operating system. Windows older versions are not allowed. (Operating systems that provide only foreground/background operation, or are based on concurrent DOS, are unacceptable and will be rejected.)
4. Processor: 8th Generation Intel Core i5, 6-core, 3 GHz base frequency, 6 MB cache.
5. RAM: The system shall come standard with at least 256K RAM disk cache and 4 gigabytes of system RAM. Provide 4 DIMM slots with capacity for up to 16 GB.
6. High Resolution Color Monitor: Provide with a 19-inch (482 mm) LCD flat panel 0.29 dot pitch Super VGA (1280 X 1024 resolution @ 60, 75 Hz) color monitor and driver.
7. Video Card: 256 megabyte of video RAM, dual-monitor capability, Blu-ray disc compatibility.
8. Hard Drives: 2 drives, at least 2 TB capacity each for optical drives, 256 GB capacity each for solid state drives.
9. CD-DVD +/- RW Drive: Read/write 48xCD/16xDVD drive, with CD creator software.
10. Multi-Card Reader: Integral to the workstation, with slots for SD, MiniSD, MicroSD, and Memory Stick Pro memory cards.
11. Mouse and Keyboard: High quality bus or serial mouse with at least 3 buttons and scroll wheel. 104-key keyboard. Either mouse or keyboard shall be able to be utilized interchangeably for operator interface.
12. Modem: Phone/fax modem, where required for remote access to the ATC system.
13. Ethernet Interface: 10/100 speed. Compatible with the Owner's network, as well as control system network. Refer to Division 27 for Owner's network requirements.
14. Wireless network card, internal to the workstation, with external antenna. Compatible with the Owner's wireless network. Refer to Division 27 for Owner's network requirements.
15. USB Ports: 8 total, at least 2 front, remainder back. At least 1 front and 1 back shall be USB 3.1; remainder shall be USB 2.0.
16. Fire-Wire Ports: IEEE 1394 interface standard. At least 1 each of IEEE 1394a and IEEE 1394b, front or rear.
17. Printer: Color, ink-jet type as follows:
    a. Print Head: 4800 x 1200 dpi optimized color resolution.
    b. Paper Handling: Minimum of 100 sheets.
    c. Print Speed: Minimum of 17 ppm in black and 12 ppm in color.

18. Accessories: Provide interconnecting cables and other accessories as required.
19. Security Software: Install anti-virus, anti-spyware, and firewall software provided by the Owner. Contact the Owner for requirements.

B. Equipment controllers shall be 16 bit microprocessor based with EPROM operating system (O.S.). ATC programs and data files shall be non-volatile EEPROM or flash memory to allow simple additions and changes. Each equipment controller shall have an on-board real-time clock with battery backup of a minimum of 30 days.
   1. Equipment controllers shall be provided where indicated or specified with capacity to accommodate input/output (I/O) points required for the application plus spare points specified. These panels shall be configured with analog and digital inputs and outputs, and pulse counting totalizers and such that the primary input, the output and control logic shall be resident in a single microprocessor to provide network independent stand-alone closed loop ATC.
   2. Panel electronics shall be installed in suitable enclosures. Equipment room panels shall have hinged doors and shall also contain the load relays, transducers, and associated equipment.

C. Terminal Equipment Controllers shall be EEPROM based and modularity expandable to accommodate additional points if required for future functional changes or enhancements, and with I/O selected for the application plus specified spares. Terminal controllers shall be capable of processing sensor signals of the applications specified, and shall have capability to drive digital (on-off), pulse width modulation, and true analog (0-10V) outputs. Terminal Controller enclosures shall be compact, finished steel to fit within or on terminal equipment. Each terminal controller shall have complete standalone capability.

2.5 OPERATOR STATION SOFTWARE

A. Operator Station (OS) software shall include as a minimum the Operating System, Data Base Manager, Communications Control, Operator Interface , Trend and History Files, Report Generator, and Support Utilities.
   1. Real time operating system shall be true multi-tasking providing concurrent execution of multiple real time programs and custom program development.
   2. Data Base manager is to manage data on an integrated and non-redundant basis. It shall allow additions and deletions to the data base without any detriment to the existing data.

B. Operator Interface Software:
   1. Operator access to the system is to be under personal ID and password control for up to 100 unique operators.
   2. Up to 100 frequently addressed system points shall be definable as "quick access" points. Each points user address, descriptor, and value/status shall be displayed.
   3. Points (physical and pseudo) shall be displayed with dynamic data provided by the system with appropriate text descriptors, status or value, and engineering unit. Points shall be dynamic and shall continuously update anytime their field status/value changes.
   4. An on-line context-sensitive help utility shall be provided to facilitate operator training and understanding.
   5. Electronic messaging facility shall be provided on the operator station for any operator to enter a message to another operator.

C. Site Specific Customizing Software:
   1. Provide software which will allow the user to modify and tailor the temperature control

to the specific and unique requirements of the equipment installed, the programs implemented, and to staffing and operational practices.

2. Point alarms shall be user-classifiable as critical or non-critical. Critical alarms shall be displayed in a dialog box of the color monitor. Display shall include time and date of occurrence, indication of alarm condition, analog value or status, user address, and alarm message.
3. A discrete per point detailed alarm-action taking message of up to 480 characters shall be available for each point.
4. Alarms shall be directed to the user selected alarm printer.
5. Non-critical alarms shall only output to the printer and OS disk in order of occurrence.
6. Run time limit messages shall be presented and processed as alarm messages except the action message shall be of a maintenance directive nature.

D. Dynamic trends shall provide for each OS of up to eight user selected points to show real time activity of the associated points. This information shall be printed and/or displayed in numeric, bar chart, curve plot, pie chart, and other formats, as selected by the operator.

E. Standard Reports Shall Be Provided Which Shall Be Output onto the Selected Report Printer. The Following Standard Pre-formatted Reports Shall Be Provided:
1. The user shall be provided with a command trace feature selectable on a per point basis allowing the archiving of commands issued to each point.
2. A custom report capability shall be provided to allow the user to format reports of any mix of text, points with status/value and descriptors, and points with status/value only.
3. Alarm history. The last 4000 alarm events shall be disk archived. Viewing or printing shall be by entering a date range (from-to).
4. Operator activity. Operator activity shall be archived. Viewing or printing shall be by entering a desired date range.
5. Trend reports shall allow the operator to randomly select point archival. Equipment controllers trend points (hardware and software) shall be assignable to PC archive files for display at user selectable intervals of 10 seconds to 24 hours.

F. Equipment controllers shall be up-line or down-line loadable to or from the OS disk for backup archival.

G. Provide software to execute and observe diagnostics of any remote device connected to the peer bus and the ability to deactivate and restart the device.

H. In addition, a word processing utility, graphics package, and spreadsheet shall be available for generic use. The base system software shall include a CRT "windowing" feature to allow the operator to monitor the real time system and use third party software simultaneously.

2.6 GRAPHIC PROGRAMMING

A. Graphic Programming. Provide hardware and software required for complete equipment controllers ATC programming of plant programs including plant system schematic development, I/O hardware point definition, hardware and software text point descriptors, ATC algorithmic development, a controller software loading utility, and a live programming test facility. At a minimum, the following shall be provided in the graphics package:
1. Boilers - control and status.
2. Heating water pump - control and status.
3. Heat recovery pump - control and status

4. Exhaust fans- control and status
5. Floor plans showing temperature sensors - control and status.
6. Air handling units, makeup air units, rooftop HVAC units and associated pumps, fans, dampers - control and status.

B. Provide a Boolean logic switching table matrix module for building ON-OFF commands from combinations of and or functions.

C. Provide a program testing utility which allows live and dynamic monitoring of the graphically displayed control programs provided.

D. In addition to training specified elsewhere in this Specification, provide 4 days of additional programming training, at a minimum of 4 hours training per day. These 4 days of additional training shall be provided during the 1 year warranty period. They are intended for use by the Owner as questions regarding system operation arise. Coordinate with the Owner.

E. Provide 2 sets of programmer's manuals.

2.7 CONTROLLER SOFTWARE

A. Energy Management application programs and associated data files shall be in non-volatile memory.
1. Optimum Start shall delay equipment start-up based on global outdoor temperature, space temperature, and system response to assure that comfort conditions are reached at scheduled occupancy. The optimum start program shall operate fully stand-alone in the local equipment controllers.
2. A load reset program shall be provided to assure that only the minimum amount of heating, cooling, and electrical energy is supplied to satisfy zone temperature requirements.

B. Control Software:
1. Each equipment controllers shall contain up to 20 unique user modifiable time programs.
2. Control Application Software shall be customized strictly to meet the detailed requirements of the "Sequence of Operation" specified hereinafter. Equipment controllers and terminal controllers shall be fully programmable. Initial software shall be fully modifiable, and not restricted by vendor's specific configuration guidelines. Equipment controllers control software shall be designed via a graphic programming facility, the detailed graphic design of which shall be provided as system documentation. Control strategies shall be advanced as noted with stabilizing setpoint ramps and procedures to assure slow loading of variable load equipment and economizer modes to prevent unsafe overshoot of controlled pressure and unsafe undershoot of mixed air temperatures during start-up and transition periods.

C. Management Software:
1. Each equipment controllers shall be provided with a trend archive of at least the last 200 events (digital transitions or analog value changes) of any user selected group of up to 20 points. A stored event shall include date and time, and value or status. Point events shall be displayable at local panels as trend logs for evaluation of control system performance.
2. Each equipment controllers shall monitor analog input points and specified digital points for off-normal conditions. Each alarm shall have an "alarm delay" attribute which shall determine how long (in seconds) a point must be in an off-normal state prior to being

considered in an alarm state.

D. Communications Software: Each equipment controllers shall have a full master peer-to-peer communications module to support global data sharing, hierarchical control, and global control strategies specified.

2.8 DATA COMMUNICATIONS

A. Equipment controllers shall be interconnected via a primary communications network. Terminal controllers shall also be connected together via secondary networks to provide data concentration and parallel processing. Networks shall support sensor sharing, global application programs, and bus-to-bus communications without the presence of a host PC.

B. The equipment controller's communications network shall support true peer protocol such that loss of any single device will not cause total bus failure.

2.9 GENERAL

A. ATC setpoints, reset schedules, time programs, historical trends shall be displayable at local ATC panels and on the system’s operator workstations.

B. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with 3-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA).
6. Tri-State Outputs: Provide two coordinated binary outputs for control of 3-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.

C. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-microsecond response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

D. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:
1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.10 SPARE POINTS

A. Provide a minimum of 10 percent spare points or 16 spare points, whichever is greater, in each ATC control panel for future use. Spare points shall be equally distributed among analog input, analog output, digital input and digital output. It is not intended that spare points be provided in unitary control panels which serve VAV boxes, unit ventilators, fan coil units and heat pumps. It is intended that spare points be provided in master control panels and in panels which serve boiler/mechanical rooms and major equipment such as air handling units.

2.11 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 27, provided under this Section.

2.12 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or 2-position action.
   1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
   1. Manufacturers:
      a. Belimo.
   2. Valves: Size for torque required for valve close-off at maximum pump differential pressure.
      a. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running torque of at least 150 lbf-in. (16.9 N-m) and breakaway torque of at least 300 lbf-in. (33.9 N-m).
      b. Spring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running and breakaway torque of at least 150 lbf-in. (16.9 N-m).
   3. Dampers: Size for running torque as recommended by the damper manufacturer for tight sealing under design operating static pressures and velocities. Submit damper manufacturer’s torque chart in same submittal as actuator selection table.
      a. For dampers which do not list torque values, provide torque calculated as follows:
         1) Damper with Edge Seals: 7 inch-lb/sq. ft. (8.6 N-m/sq. m) of damper.
         2) Damper without Edge Seals: 5 inch-lb/sq. ft. (6.22 N-m/sq. m) of damper.
      b. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft (2.3 sq. m): Size for running torque of at least 150 lbf-in. (16.9 N-m) and breakaway torque of at least 300 lbf-in. (33.9 N-m).
      c. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft (2.3 sq. m): Size for running and breakaway torque of at least 150 lbf-in. (16.9 N-m).
      d. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by a factor of 1.5.
      e. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by a factor

of 2.0.

4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (2-Position Spring Return): 24-V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: 40 to 104°F (5 to 40°C).
    a. In addition, valve actuators shall be suitable for the anticipated ambient temperature and fluid temperature. For example, actuators located within heating equipment terminal enclosures will experience higher temperatures.
11. Temperature Rating (Smoke Dampers): -22 to 250 degrees F (-30 to 121 degrees C).
12. Run Time: 30 seconds.
13. Actuator Housing: Molded or die-cast zinc or aluminum. Terminal unit actuators may be high-impact plastic with ambient temperature rating of 50 to 140 degrees F (10 to 60 degrees C) unless located in return-air plenums.
14. Damper actuators shall be provided with end switches.

2.13 CONTROL VALVES

A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
   1. Globe-type valves are required except for those applications where terminal-unit control valves or butterfly valves are specified or detailed.
   2. Ball-type valves may be substituted for other types, and shall be manufactured by Belimo, with Belimo actuators (no substitutions).
   3. Valves shall be suitable for water with up to 50 percent inhibited ethylene or propylene glycol.
   4. 3-way valves shall be mixing pattern, except where diverting pattern is specified, or where manufacturer requires use of diverting pattern.
   5. Rubber-paddle or ball-plug type control valves such as, but not limited to, Honeywell Fan-Coil Valves or the TAC Erie product line (division of Schneider Electric) are not allowed.
   6. Valves with thermal-wax motors are not allowed.
   7. Valves requiring cartridge replacement for service are not allowed.
   8. Valves requiring special water treatment such as 50-micron filtration are not allowed.

B. Sizing: Maximum pressure drop determined with valve full-open at design flow rate and the following:
   1. 2 Position: Line size.
   2. 2-Way Modulating: Between one-half and one times the variable-flow load pressure drop, but not to exceed 3 psig (21 kPa).
   3. 3-Way Modulating: Between one-half and one times the variable-flow load pressure drop, but not to exceed 1.5 psig (10.5 kPa).
   4. Note: For modulating valves, the load pressure drop is that across the modulated portion of the system. For example, for a 3-way valve providing reset-water control at a boiler, the modulated flow is across the boiler and accessories, whereas the building loop to terminal equipment is considered constant-flow for the purposes of this valve's sizing. For a 3-way valve modulating the flow thru a coil, the coil and its pipe fittings comprise

the variable-flow load. For a 3-way valve in a primary-secondary loop to a coil, where the flow thru the coil is a constant pumped flow, the variable load is in the primary-secondary bridge.

C. Hydronic system globe valves shall have the following characteristics:
   1. NPS 2 (DN 50) and Smaller: Class 125 bronze (or red brass) body, bronze or brass seat, bronze trim, rising stainless steel stem, renewable brass or composition disc or plug, screwed ends, with backseating capacity, repackable under pressure. Valve may have integral union ends. Valves with ends other than threaded or factory-integral unions are not allowed.
   2. NPS 2-1/2 (DN 65) and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
   3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
      a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
      b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.
   4. Flow Characteristics: 2-way valves shall have equal percentage characteristics; 3-way valves shall have linear characteristics through 1 of the ports, equal percentage through the other.
   5. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for 2-way valves, and 100 percent of pressure differential across valve or 100 percent of total system (pump) head for 3-way valves.
   6. Temperature Rating: 250°F (121°C).

D. Butterfly Valves: 200-psig (1380-kPa), 150-psig (1034-kPa) maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
   1. Body Style: Wafer or lug.
   2. Disc Type: Nickel-plated ductile iron or aluminum bronze.
   3. Seat: EPDM resilient seat replaceable. Disc may be coated, but primary sealing surface shall be the resilient seat mounted in the body.
   4. Sizing: 1-psig (7-kPa) maximum pressure drop at design flow rate.
   5. Temperature Rating: 250°F (121°C).

E. Terminal Unit Control Valves: Bronze body, bronze trim, 2 or 3 ports as indicated, replaceable plugs and seats, and union and threaded ends. Valves with ends other than threaded or factory-integral unions are not allowed.
   1. Applications: Duct-mounted reheat coils, and fintube radiation. For other applications, see globe valve specifications above.
   2. Honeywell "small linear control valves" with "linear valve actuators" (or equal) may be used only for VAV box coils and hot water duct coils; they may not be used for other coil or equipment types.
   3. Rating: Class 125 for service at 125 psig (860 kPa) and 250 deg F (121 deg C) operating conditions.
   4. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating sufficient to close against pump shutoff head.
   5. Flow Characteristics: 2-way valves shall have equal percentage characteristics; 3-way valves shall have linear characteristics.

2.14 DAMPERS

A. Manufacturers:
   1. Non-Insulated Dampers:
      a. Ruskin - Model CD60.
      b. American Warming & Ventilating.
      c. Arrow.
      d. Greenheck.
      e. Tamco (T.A. Morrison & Co., Inc.).
   2. Insulated-Blade Dampers:
      a. T.A. Morrison & Co., Inc.; Tamco Series 9000 SC "Severe Cold Option" dampers.
      b. Greenheck – Series ICD-45.
      c. Ventex, Inc. - Series 3965SI.

B. Non-Insulated Dampers:
   1. AMCA-rated, parallel (2-position) or opposed-blade (modulating) design.
   2. Frames shall be 16 gauge (1.6 mm) thick galvanized steel, reinforced to equivalent strength of 11 gauge (3 mm) galvanized steel; or 0.125 inch (3.2 mm) minimum thickness extruded-aluminum.
   3. Blades shall be airfoil type of not less than 14 gauge (2 mm) equivalent thickness galvanized steel or heavy gauge extruded aluminum, with maximum blade width of 8 inches (200 mm) and length of 48 inches (1220 mm).
   4. Secure blades to 1/2 inch (13 mm) diameter, hex-profile, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze or nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
   5. Operating Temperature Range: From -40 to 200 degrees F (-40 to 9 degrees C).
   6. Edge Seals, Low-Leakage Applications: Replaceable, inflatable blade edging of Ruskiprene, neoprene, vinyl, or rubber, and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm/sq. ft (50 l/s per sq. m) of damper area, at differential pressure of 4-inch wg (1 kPa) when damper is held by torque of 50 in.-l bf (5.6 N-m); when tested according to AMCA 500D-98.

C. Insulated Dampers: Dampers which are located in or 4 ft. (1.2 m) or less from outside walls or roof lines, and are 8 sq. ft. (0.74 sq. m) or larger, shall be thermally insulated type.
   1. Frame: Extruded aluminum, externally insulated with polystyrene foam.
   2. Blades: Double wall extruded aluminum, with internal injected polyurethane foam, thermally broken. Extruded silicone frame and blade seals, secured in slots in the aluminum extrusions. R-value of complete blade shall be 2.29 hr-ft2-F/Btu (0.39 m2- K/W).
   3. Leakage shall not exceed 4.9 cfm/sq. ft (25 l/s per sq. m) against 4 in. wg (1 kPa) differential static pressure at -40 degrees F (-40 degrees C).
   4. Bearings: Celcon inner bearing fixed to a 7/16 inch (11.1 mm) aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.
   5. Linkage Hardware: Installed in the frame side, constructed of aluminum and corrosion-resistant, zinc-plated steel, with cup-point trunnion screws for a slip-proof grip.
   6. Operating Temperatures: -40 to 155 degrees F (-40 to 68 degrees C).
   7. For dampers less than 12 inches (305 mm) in 1 dimension, provide "flanged-to-duct" mounting style for maximum free area.

D. Automatic dampers at exterior wall louvers shall be 4 inches (100 mm) shorter in vertical dimension (height) than the louver they serve, to allow sloping of bottom of duct to drain outward. Depending on the height of the louver's integral waterstop, it may be necessary to slope the top of the duct as well as the bottom. Coordinate sizing and positioning of dampers and louvers with Division 23 Section "Air Inlets and Outlets" to ensure that base of damper frame is positioned higher than the lowest edge of the duct where it laps over the top edge of the louver's waterstop or bottom blade. It shall be the responsibility of this Section to ensure proper installation to drain.

2.15 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:
1. Accuracy: Plus or minus 0.5°F (0.3°C) at calibration point.
2. Wire: Twisted, shielded-pair cable.
3. Insertion Elements in Ducts: Single point, 8 inches (200 mm) long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).
4. Averaging Elements in Ducts: 36 inches (915 mm) long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft. (1 sq. m).
5. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches (64-mm).
6. Room Sensor Cover Construction: See below.
7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
8. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

C. Pressure Transmitters/Transducers:
1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
   a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   b. Output: 4 to 20 mA.
   c. Duct Static-Pressure Range: 0- to 5-inch wg (0 to 1240-Pa).
2. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure and tested to 300-psig (2070-kPa); linear output 4 to 20 mA.
3. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.

D. Room Sensor Cover Construction: Manufacturer's standard locking covers.
1. Set-Point Adjustment: Concealed.
2. Set-Point Indication: Concealed.
3. Thermometer: Concealed.
4. Communications Port: Standard phone-type jack for connection of portable laptop computer and other devices. Provide at each room sensor, no exceptions.
5. Override Pushbutton: For timed override of occupied/unoccupied cycle. Provide in normally-occupied rooms such as classrooms, shops, offices, cafeterias, kitchen, lecture hall, band and chorus rooms, and gymnasiums. Do not provide in storage rooms, stairs, entries, vestibules, corridors, elevator machine rooms, electrical rooms, Comm rooms,

and mechanical rooms.

E. Room sensor accessories include the following:
   1. Insulating Bases: For sensors located on exterior walls.
   2. Adjusting Key: As required for calibration and cover screws. Furnish to the Owner, at least 5 per sensor type.
   3. Guards:
      a) Cast aluminum, with large openings for easy viewing of sensor, rounded surfaces to prevent injury, equivalent to Siemens Model 134-117 thermostat guard or Kele Model AT-1104.
      b) Lockable, vented low-profile clear plastic guard equivalent to Kele BAPI-Guard Series.
      c) Lockable, vented clear plastic guard with opaque solid wall plate, equivalent to Kele TG500 Series.
   4. Wall Mounting Box: Recessed, steel, securely fastened to wall framing. Equal to Steel City metallic switch boxes by Thomas & Betts Corp. Box may only be omitted where sensor attaches directly to masonry construction.

2.16 THERMOSTATS AND TEMPERATURE SENSORS

A. Thermostats and Sensors in locations in regular view by the occupants shall have covers which are simple, aesthetically pleasing, neutral in color, with manufacturer's logo, if any, in black or neutral color, and shall fit flush to the surrounding wall surface.

B. Freezestats:
   1. Freezestat safety low limits shall be duct-mounted manual-reset and automatic-reset (see control sequences) 20-foot limited fill capillary-tube type, responsive to the coolest section of its length.
   2. Air handling systems which handle outside air (or a mix of outside air and return air) or are located outdoors shall have freezestats at hydronic and steam coils. Where freezestats are required, provide both a manual-reset type set near freezing temperature for shutdown, and an automatic-reset type set at a warmer temperature for preventive action.
   3. Air handling systems with chilled-water coils mounted upstream of heating coils shall have freezestats on the upstream face of the chilled water coils, in addition to the freezestats on the downstream face of the heating coils.

C. Thermostats
   1. Electric thermostats shall be line voltage or low voltage type, suitable for the application. They shall have concealed setpoint adjustment and setpoint indicator. Electric thermostats shall be provided with manual adjustment dials and shall be protected by lockable tamper proof covers.
   2. Unit heater aquastats shall be strap-on type.

D. Temperature Sensors:
   1. Temperature sensors shall provide a 2-wire connection to the controller that is polarity and wire type insensitive. Sensors shall have communications jacks for connection to the communication trunk to which the controller is connected. The temperature sensor, the connected controller, and other devices on the communications bus shall be accessible by the Graphical Programming tool.
   2. Provide with manual adjustment rotary or sliding dials, with a scale labeled as either

temperature in degrees F, or "warmer/cooler". The input from this dial shall be programmable through the operator workstation to allow a maximum and minimum range for user adjustment. The min/max range shall initially be set at 4°F above/below the programmed setpoint. When the dial is adjusted, it shall shift both heating and cooling setpoints by the programmed amount, in proportion to the distance moved. This dial shall only affect the occupied setpoints; the unoccupied setpoints shall remain as programmed.

3. Provide with override buttons which, when depressed during unoccupied time periods, will override the zone's temperature controls and setpoints to occupied conditions for a user adjustable period of time (initially set for 2 hours).

E. Tamper-Resistant Covers and Guards:

1. Provide protective lockable guards for thermostats and temperature sensors located in high traffic and unsecure areas. These areas shall include, but not be limited to:
   a. Cafeteria.
   b. Corridors.
   c. Lobbies.
   d. Locker Rooms.
   e. Public Toilet Rooms.
   f. Stairways.
   g. Storage Areas.
   h. Technology Lab.
   i. Vestibules.
   j. Weight Room.

2. Provide tamper-resistant blank covers (without manual adjustments, temperature indicators, or override buttons) for thermostats and temperature sensors located in the following areas:
   a. Closets.
   b. Corridors.
   c. Locker Rooms.
   d. Production Area.
   e. Stairways.
   f. Storage Areas.
   g. Toilet Rooms.
   h. Vestibules.

3. Provide tamper-resistant semi-blank covers (without manual adjustments or temperature indicators, but including override buttons) for thermostats and temperature sensors located in the following areas:
   a. Lobbies.
   b. Teachers' Lounge.

2.17 STATUS SENSORS

A. Where differential pressure "sensor" is indicated or specified, they shall be analog-output type as specified herein. Where differential pressure "switch" is indicated, it may be digital-output type.

B. Status Inputs for Fans: Unless otherwise specified: Differential-pressure switch with pilot-

duty rating and with adjustable range of 0- to 5-inch wg (0 to 1240 Pa).

C. Status Inputs for Pumps: Unless otherwise specified: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa), piped across pump. Pumps with motors 1 hp or smaller may use current transformers (CTs) for status inputs.

D. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

E. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

F. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4-20 mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

G. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

H. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

I. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.18 CURRENT TRANSFORMERS

A. Current transformers (CTs) are not an acceptable substitute for pump or fan monitoring where flow switches or pressure switches are specified.

B. Provide CTs as required for the sequences of operation specified.

2.19 DIFFERENTIAL WATER PRESSURE SENSORS

A. Manufacturers:
1. Setra - Model 230 Wet-to-Wet Pressure Transducer.
2. Ashcroft.
3. Honeywell.
4. Johnson Controls.

B. At Contractor’s option, Setra Model 231RS wet-to-wet multi-range differential pressure transducer with remote-wired sensors may be used.

C. Differential-pressure monitoring shall be analog-output type unless otherwise specified.

D. High output, low differential pressure transducer designed for wet to wet differential pressure measurements of liquids or gases. A fast-response capacitance sensor and signal conditioned electronic circuitry provide a highly accurate, linear analog output proportional to pressure.

Both unidirectional and bidirectional pressure ranges are available for applications with line pressure up to 250 psig.

E. An isolation system transmits the motion of the differential pressure sensing diaphragm from the high line pressure environment (e.g. corrosive liquids) to the dry (air) enclosure where it moves one of a pair of capacitance plates proportionally to the diaphragm movement. Response to pressure changes is approximately 20 times faster than conventional fluid-filled transducers. The electronic circuit linearizes output vs. pressure and compensates for thermal effects of the sensor.

F. NEMA 4/IP65 rated enclosure. Pipe-thread fittings.

G. Accuracy RSS (of non-linearity, non-repeatability and hysteresis) (at constant temperature) +/- 0.25 percent of full scale (pressure range).

H. Pressure Range: Selected by the Contractor for the anticipated or field-measured (actual) pressure differential. Lower ranges have greater accuracy.

I. Ambient Operating Temperature for Electronics: 0 to 175°F (-18 to 79°C).

2.20 DIFFERENTIAL WATER PRESSURE SWITCHES

A. Differential-pressure switches with on/off contact closure output may be used where specified.

B. NEMA 2 minimum enclosure. Pipe-thread fittings. Brass or bronze wetted parts.

C. Ambient Operating Temperature for Electronics: 30 to 158°F (-1 to 70°C).

2.21 CARBON DIOXIDE SENSOR

A. Indoor Carbon Dioxide Sensor and Transmitter: Greystone CDD Series. Single detectors using solid-state non-dispersive infrared sensors; suitable over a temperature range of 32 to 122°F (0 to 50°C), calibrated for +/- 3 percent of reading at 72°F (22°C), with continuous or averaged reading, stability less than 2 percent full scale over life of sensor (15 years typical), self-calibrating. 4-20 mA or 0-10 Vdc output; 5 amp relay output; status LED; LCD display of PPM level with 1 ppm resolution. Enclosure for wall mounting or duct mount, depending on application. For wall-mounting in occupied spaces, provide Greystone's "Corporate Space" enclosure or other manufacturer's equivalent. Provide Modbus communications where applicable.

2.22 ROOM OCCUPANCY DETECTION EQUIPMENT

A. Carbon Dioxide Sensor and Transmitter: See "Carbon Dioxide Sensor" in this Section.

B. Occupancy Sensor: Provided by Division 26.

2.23 REFRIGERANT LEAK DETECTORS

A. Manufacturers:
   1. Bacharach, Inc. - HGM-MZ multizone.
   2. Parasense, Inc.

B. Product Type: Multiple-area monitoring system for low level continuous monitoring of refrigerant gases used in most commerial systems including: CFC, HCFC, HFC and Ammonia. System design supports compliance with gas monitoring requirements of ANSI/BSR ASHRAE 15-1994.

C. Gas Library:
1. CFC: R-11, R-12, R-113, R-114, R-502, HFP.
2. HFC: R-404a (HP62), R-407a, R-407c (AC9000), R-134a, R-410a (AZ20), R-507 (AZ50), R-508b (SUVA95), R236FA, R125, R245Fa, R422a, R422d, R427a.
3. HCFC: R-22, R-123, R-124, R-500, R-503, R-401a (MP39), R-402a (HP80), R-402b (HP81), R-408a, R-409a, R-23, R21, R227.
4. Halon: H1301,H2402, H1211.
5. Other: FA188, FC72, N1230.

D. Front Panel: 3 indicator lights.
1. Green: Monitor is powered on. LED glows during normal operation; flashes when unit is in warm-up mode.
2. Red: Alarm. LED flashes when any point has exceeded the alarm setting.
3. Yellow: Fault. LED flashes when there is a system fault.

E. Performance:
1. Sensitivity: 1 ppm (exception is R11: +/- 10 ppm +/- 15 percent of reading 0-1000 ppm).
2. Measuring Range: 0 to 10,000 ppm.
3. Accuracy: +/- 1 ppm from +/- 10 percent of reading from 1-1000 ppm (exception is R-11: +/- 10 ppm +/- 15 percent of reading 0-1000 ppm).
4. Temperature Drift: +/- 0.3 percent of reading per degree C.
5. Coverage: 4 point (zone) standard, expandable to 16 points in 4 point increments.
6. Detector Type: Infrared Non-Dispersive.
7. Sampling Mode: Automatic or Manual (hold).
8. Re-Zero: Auto or on Zone Change.
9. Response Time: 5 to 120 seconds - depending on air-line length and number of zones.
10. System Noise: Less than 40 dB(A) at 10 feet (3 m).
11. Monitoring Distance: 1,200 ft. maximum for combined length of sample + exhaust tubing (each zone).
12. Conditional System: Dual optional 4-20 mAdc isolated outputs. Channel 1: zone area. Channel 2: PPM.
13. Alarms:
    a. 4 SPDT alarm contacts (rated 5 Amps at 250 volts). 3 assigned to PPM level alarms, 1 assigned to system faults.
    b. Audible alarm at panel, with silencing feature.
14. Communications: RS-232C communication port standard. Provide full 2-way communication with building management system via RS485 MODBUS-RTU serial interface.
15. Power Safety Mode: Fully automatic system reset. Programmed parameters retained
16. Operating Temp: 32 to 122°F (0 to 50°C).
17. Ambient Humidity: 5 to 90 percent RH (non-condensing).
18. AC Power: 100 to 240 VAC, 50/60 Hz, 20 W.
19. Altitude Limit: 6,562 ft. (2,000 m).
20. Fusing: F1, F2: 1.0 A, 250 VAC, Type “F”.
21. Sensor Life: 7-10 years.

F. Certification: UL 61010-1, Can/CSA 22.2 No. 61010-1 & CE Mark.

G. Warranty: 2 years from date of shipment.

H. Accessories:
1. Surge protector.
2. Tubing and supports for sample intake lines, purge line, and exhaust line.
3. End-of-line filters.
4. Charcoal filter for purge line.
5. Splitter kits for multiple filters on a single zone.
6. Water trap.
7. Spare fuses.
8. Annual maintenance kit, including line end filters in quantity to match installation, 1 charcoal filter, 1 hydrophobic filter, and 3 end-of-line water stop filters.

I. Zones:
1. As shown on plans.

J. For installation of relief valve end-of-line filter, provide end of relief copper piping turned downward to shed water and snow, and enlarge end of piping so that net area of piping with filter installed is not less than the area of the relief main.

2.24 AIRFLOW MEASURING STATIONS

A. Manufacturers:
1. EBTRON, Inc. Model GTx116 P and GTx116 F (basis of design).
2. Air Monitor Corporation.
3. Ruskin.

B. Verify quantities, sizes, and locations of measuring stations to meet the intent of the specified control sequences, and provide as required. Coordinate with other Sections of the Specifications and other trades, to provide installation in ductwork, air handling units, and other locations as required.

C. Warranty: Provide a manufacturer's parts warranty for 36 months from the date of unit shipment.

D. Submittals:
1. Submit product data sheets for airflow measuring devices indicating minimum placement requirements, sensor density, sensor distribution, and installed accuracy to the host control system.
2. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this Specification throughout the measurement range.
3. Submit a schedule of airflow measuring devices indicating compliance with specified accuracy at minimum and maximum airflow rates.
4. Submit installation, operation and maintenance documentation.

E. Each measurement device shall consist of one or more sensor probe assemblies and a single microprocessor based transmitter. Each sensor probe assembly shall contain one or more independently wired sensor housings. Multiple sensor housings shall be equally weighted and

averaged by the transmitter prior to output. Pitot tubes and arrays are not acceptable. Vortex shedding flow meters are not acceptable.

F. Sensor Probe Assemblies:
1. Each sensor housing shall be manufactured of a U.L. listed engineered thermoplastic.
2. Each sensor housing shall utilize two hermetically sealed, bead in glass thermistor probes to determine airflow rate and ambient temperature. Devices that use "chip" type thermistors are unacceptable. Devices that do not have 2 thermistors in each sensor housing are not acceptable.
3. Each sensor housing shall be calibrated at a minimum of 16 airflow rates and have an accuracy of +/ 2 degrees of reading over the entire operating airflow range. Each sensor assembly shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).
   a. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this Specification throughout the measurement range.
4. The operating temperature range for the sensor probe assembly shall be 20 to 160 degrees F (-28 to 71 degrees C). The operating humidity range for the sensor probe assembly shall be 0 to 99 percent RH (non-condensing).
5. Each temperature sensor shall be calibrated at a minimum of 3 temperatures and have an accuracy of +/ 0.15 degrees F (0.08 degrees C) over the entire operating temperature range. Each temperature sensor shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).
6. Each sensor probe assembly shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to a remotely mounted transmitter. Terminal plug interconnecting pins shall be gold plated.
7. Each sensor assembly shall not require matching to the transmitter in the field.
8. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter at a given measurement location.

G. Duct and Plenum Sensor Probe Assemblies:
1. Sensor housings shall be mounted in an extruded, gold anodized, 6063 aluminum tube probe assembly.
2. The number of sensor housings provided for each location shall be as follows:
   a.

Area (sq.ft.)	Area (sq.m)	Sensors
≤1	(≤0.09)	2
>1 to <4	(>0.09 to <0.37)	4
4 to <8	(0.37 to <0.74)	6
8 to <12	(0.74 to <1.11)	8
12 to <16	(1.11 to <1.49)	12
≥16	(≥1.49)	16

3. Probe assembly mounting brackets shall be constructed of Type 304 stainless steel. Probe assemblies shall be mounted using one of the following options:
   a. Insertion mounted through the side or top of the duct.
   b. Internally mounted inside the duct or plenum.
   c. Standoff mounted inside the plenum.
   d. The operating airflow range shall be 0 to 5,000 FPM (0 to 56 m/s) unless otherwise indicated on the Drawings.

H. Fan Inlet Sensor Probe Assemblies:
1. Sensor housings shall be mounted on 304 stainless steel blocks.

2. Mounting rods shall be field adjustable to fit the fan inlet and constructed of nickel plated steel.
3. Mounting feet shall be constructed of 304 stainless steel.
4. The operating airflow range shall be 0 to 10,000 FPM (0 to 113 m/s) unless otherwise indicated on the Drawings.

I. Transmitters:
1. The transmitter shall have an LCD display capable of displaying airflow and temperature. Airflow shall be field configurable to be displayed as a velocity or a volumetric rate.
2. The transmitter shall be capable of displaying the individual airflow and temperature readings of each sensor on the LCD display.
3. The transmitter shall operate on 24 VAC. The transmitter shall not require an isolated power source.
4. The operating temperature range for the transmitter shall be 20 to 120 degrees F (-28 to 48 degrees C). The transmitter shall be protected from weather and water.
5. The transmitter shall be capable of communicating with the host controls using one of the following interface options:
   a. Linear analog output signal: Field selectable, fuse protected and isolated, 0 10VDC and 4 20mA (4 wire).
   b. RS 485: Field selectable BACnet MS/TP, ModBus RTU and Johnson Controls N2 Bus.
   c. 10 Base T Ethernet: Field selectable BACnet Ethernet, BACnet IP, ModBus TCP and TCP/IP.
   d. LonWorks Free Topology.

J. The measuring device shall be UL listed as an entire assembly.

K. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the Drawings. Submit a written report to the Architect if any measurement locations do not meet the manufacturer's placement requirements.

L. Airflow measuring stations shall be interfaced with Division 23 Section “Instrumentation and Controls for HVAC” so that the building's ATC system shall monitor airflow. Coordinate output signal with Division 23 Section “Instrumentation and Controls for HVAC”. Any controllers required for the proper operation of the airflow monitoring station shall be LonWorks compliant.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that power supply and data outlet is available to control units and operator workstation.

3.2 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Wiring and conduits shall be properly supported and run in a neat and workmanlike manner. Wiring and conduits exposed and in equipment rooms shall run parallel to or at right angles to the building structure. Wiring and conduits within enclosures shall be neatly bundled and

anchored to prevent obstruction to devices and terminals. Wiring, conduits, wall boxes, and accessories shall conform to Division 26 – Electrical, and Division 27 of the Contract Documents.

B. The ATC Contractor shall be responsible for electrical installation, including any low voltage and line voltage wiring which is required for a fully functional control system and not indicated on the Electrical Drawings or required by the Electrical Specifications (Divisions 26 and 27).

C. Wiring shall be in accordance with local and national Codes and regulations.

D. Provide electrical materials and installation under this Section. Requirements and standards shall be as specified in other Sections and Divisions of the Specifications, as indicated in paragraphs below.
   1. Install raceways, boxes, and cabinets in conformance to Division 26.
   2. Install building wire and cable in conformance to Division 26.
   3. Provide interface wiring (line and low voltage) as required to complete ATC system installation.
   4. Install signal and communication cable according to Division 27.
      a. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
      b. Install exposed cable in raceway.
      c. Install concealed cable in raceway.
      d. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
      e. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
      f. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
      g. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

E. Control wiring in boiler room, mechanical rooms, and equipment rooms shall be installed in conduit which shall comply with the requirements of the Electrical Specifications.

F. Electronic low-voltage wiring shall be #18 AWG minimum THHN and shielded if required.

G. Provide power for normally-openduct reheat coil, fintube, and glycol system,hot water valves from a central source(s). Interlock with hot water pump(s) to de-energize valves when pump is de-energized.

H. Power for any temperature control panels required in addition to those indicated on the Drawings shall be the responsibility of this Section. Power to temperature control panels shall be through “stand-by” power circuits which are powered through the building’s emergency generator.
   1. It is the design intent to have the entire temperature control system, including damper and valve actuators, powered by stand-by power circuits to ensure that the DDC system is fully functional when the building is operating on generator power.

3.3 INSTALLATION

A. Wall mounted thermostats and temperature sensors shall be attached to an electrical wall box

attached to a wall stud, masonry wall, or to blocking. Attaching to gypsum wallboard only shall not be allowed.

B. Mounting heights of room sensors, thermostats, and other devices, which have features which occupants may adjust or set by touching, shall be installed in locations and heights conforming to U.S. Department of Justice – 2010 ADA Standards for Accessible Design.
   1. Unobstructed Forward or Side Reach: Reaches, measured by distance above the finished floor or ground surface upon which the occupant shall be sitting or standing, shall be a high of 48 inches (1220 mm) maximum measured to the top of the device, and a low of 15 inches (380 mm) minimum measured to the bottom of the device.
   2. Obstructed High Reach: Where a high forward reach is over an obstruction, the clear floor space shall extend beneath the element for a distance not less than the required reach depth over the obstruction. The high forward reach shall be 48 inches (1220 mm) maximum where the reach depth is 20 inches (510 mm) maximum. Where the reach depth exceeds 20 inches (510 mm), the high forward reach shall be 44 inches (1120 mm) maximum and the reach depth shall be 25 inches (635 mm) maximum.
   3. Coordinate with Division 26 – Electrical to match heights for an aesthetically pleasing appearance.

C. Verify location of room temperature sensors and other exposed control sensors with Drawings and room details before installation.
   1. Thermostats and temperature sensors are indicated on the Drawings for general location. Terminal heat transfer units and fans which control space temperature shall be provided with thermostatic control, whether or not a thermostat or temperature sensor has been indicated on the Drawings.
   2. Locate in the general location indicated, and coordinate to group together with room light switches and other devices of similar height, to minimize disruption of open wall space.
   3. Locate to not be above electrical dimmers.
   4. Locate to avoid heat-generating equipment such as computers, copiers, cooking equipment, coffee makers, vending machines, and refrigerators. Where electrical outlets are indicated near sensors, verify whether equipment is intended.
   5. Locate to avoid heating piping which may be concealed in partitions.
   6. Locate away from windows and exterior doors.
   7. Locate to avoid other false sources of heat such as strong sunlight.

D. Provide guards on room sensors and thermostats in the following locations:
   1. Public areas other than classrooms and offices, including but not limited to: Corridors, hallways, entrances, lobbies, vestibules, stairwells, toilet rooms, locker rooms, storage rooms, cafeterias, and gymnasiums.
   2. Locations vulnerable to traffic.
   3. Where indicated.

E. At each wall-mounted temperature sensor, provide wiring for setpoint dial and override pushbutton, and for communications jacks, whether or not the specified sensor has these functions. This will allow the Owner to change sensors to add these functions in the future. Provide access to the associated controller and related control panels through each communication jack.

F. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

G. Install freezestats serpentined across and clipped to the downstream face of coils. Entire length

of capillary tube shall be within the unit airstream.

H. Perform adjustment/relocation of freezestats as required to eliminate nuisance freezestat alarms.

I. Aquastats installed on unit heaters and at any location above 60 inches (1525 mm) above finished floor shall be installed with adjustment knobs facing downward to facilitate adjustment.

J. Outdoor air temperature sensor(s) shall be installed on the North side of the building.

K. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

L. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

M. Connect lead-lag controls to lock out the failed or non-selected motor, to prevent simultaneous operation.

N. Connect lead-lag controls so that only 1 motor can run in starter “hand” position.

O. Connect fire alarm shutdown of motors on the load side of controls and hand-off-auto switches, to prevent motor from running in any switch position during fire alarm.

P. For components to be installed under other Sections of the Specifications, provide delivery of components to appropriate Subcontractors, provide installation instructions, and supervise their installation.

Q. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."
1. Sensors shall be immersion type in wells unless otherwise specified or indicated.
2. Enlarge piping at wells to prevent excess interference with flow.
3. Locate wells to ensure insertion in active flowing section of piping or tank.
4. Fill sensor wells with Honeywell thermal heat transfer paste to ensure good conduction.

R. Install refrigerant instrument wells, valves, and other accessories according to Division 23 Section "Refrigerant Piping and Specialties."

S. Install automatic dampers in conformance to Division 23 Section "Air Duct Accessories."

T. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures. Provide stand-off brackets of depth to meet or exceed specified thickness of duct insulation.

U. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

V. Provide labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

W. Install electronic and fiber-optic cables according to Division 27.

X. Unless otherwise indicated, actuators shall be spring loaded and shall, upon a loss of power, actuate their device to an appropriate "fail safe" position.
   1. Hot water valves - fail safe to fully open.
   2. Outside and exhaust air dampers - fail safe to fully closed.
   3. Exhaust fan motorized dampers - fail safe to fully closed.
   4. Supply air dampers at rooftop units - fail safe to fully closed.
   5. Return air dampers - fail safe to fully open.
   6. Combination fire/smoke dampers - fail safe to fully closed.
   7. Boiler Room combustion air damper at upturned duct - fail safe to full open.
   8. Boiler Room combustion air damper at down turned duct - fail safe to fully closed.
   9. Boiler isolation valves (each boiler) - fail safe to fully open.

Y. For actuators that are required to "fail safe", provide spring return actuators. "Floating point" actuators shall not be allowed for these applications. "Floating point" actuators shall be allowed for actuators that are not required to "fail safe".

Z. Enter computer programs and data files into the related computers including control programs, initial approved parameters and settings, and English descriptors.

AA. Maintain CD copies of data file and application software for reload use in the event of a system crash or memory failure. 1 copy shall be delivered to the Owner during training session, and 1 copy shall be archived in the ATC Contractor's local software vault.

BB. Install software in control units and operator workstation(s). Implement features of programs to specified requirements and as appropriate to sequence of operation.

CC. Connect and configure equipment and software to achieve sequence of operation specified.

3.4 FIELD QUALITY CONTROL

A. Coordinate with the requirements of Division 01 Section "General Commissioning Requirements".

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

C. Perform the following field tests and inspections and prepare test reports:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
   2. Test and adjust controls and safeties.

D. DDC Verification:
   1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
   2. Check instruments for proper location and accessibility.
   3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
   4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
   5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.

6. Check temperature instruments and material and length of sensing elements.
7. Check control valves. Verify that they are in correct direction.
8. Check DDC system as follows:
    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

E. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:
1. Calibrate instruments.
2. Make 3-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:
    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature set points.

C. 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 3 visits to Project during other than normal occupancy hours for this purpose.

3.6 VALIDATION

A. The ATC Contractor shall completely check out, calibrate, and test connected hardware and software to ensure that the system performs in accordance with the approved submittals for specifications and sequences of operations.

B. Witnessed Validation Demonstration: Shall consist of:
   1. Display and demonstrate each type of data entry to show site specific customizing capability.
   2. Execute digital and analog commands.
   3. Demonstrate ATC loop precision and stability via trend logs of inputs and outputs.
   4. Demonstrate energy management performance via trend logs and command trace.
   5. Demonstrate that each control point, tag, or address is associated with the proper device, such as a room sensor input or an actuator output. This demonstration shall include visual confirmation that the measured values and the output actions match what is indicated in the control system.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain Mechanical instrumentation and controls. Refer to Division 01 Section "Demonstration and Training."

3.8 TRAINING

A. Training shall be by the ATC Subcontractor and shall utilize specified manuals and as-built documentation. Video record each training session, and turn the completed video over to the Owner when training has been completed.

B. Operator training shall include 10 four-hour sessions encompassing:
   1. Modifying text.
   2. Sequence of Operation review.
   3. Selection of displays and reports.
   4. Use of the specified functions.
   5. Setting and adjusting of occupancy schedules.
   6. Troubleshooting of sensors.
   7. Owner questions/concerns.

C. 2 training sessions shall be conducted at project substantial completion, and the others shall be conducted at the Owner’s request and in accordance with the Owner’s schedule within a period of 6 months after substantial completion of the project.

D. At 6 months after substantial completion, unused training hours shall be, at the Owner’s discretion, used for future training of new personnel or reimbursed to the Owner at the Subcontractor’s current hourly service rate.

3.9 MECHANICAL COMMISSIONING

A. Refer to Specification Division 01 Section “General Commissioning Requirements” - for requirements and responsibilities of the ATC Contractor.

B. Prior to the commencement of mechanical commissioning, provide validation of the temperature control system as follows:
   1. Completely check out, calibrate, and test connected hardware and software to insure that the system performs in accordance with the approved products and sequences of operations submitted.
   2. Witnessed validation demonstration shall consist of:
      a. Display and demonstrate each type of data entry to show site specific customizing capability.
      b. Execute digital and analog commands.
      c. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs.
      d. Demonstrate energy management performance via trend logs and command trace.

C. To facilitate the commissioning process, provide the ability for the Commissioning Agent to, through the graphics screens, modify the outside air temperature analog input signal to the system. The intent is to allow the Commissioning Agent to adjust the outside air temperature so that the systems can be tested during their various modes of operation (for example, dehumidification, humidification, heating, cooling.)

D. Provide support for the Commissioning Agent as required to facilitate the commissioning process. This shall include a minimum of 2 four-hour training sessions on the use of the system’s graphics and associated software. The intent is to train the Commissioning Agent so that he can perform simple commands such as adjusting room temperature setpoints for commissioning of reheat coils, fintube radiation, cabinet unit heaters, unit heaters and VAV boxes. This will allow the Commissioning Agent to perform a majority of his work without assistance. For more complicated systems such as building pressure control, control of outdoor air dampers based on CO_2 levels, control of variable frequency drives and air handling unit damper response, provide assistance as required by the Commissioning Agent during the commissioning process.

Appendix A Appendix A: Sample Graphics

A.1. Provide graphics to match images shown herein to the greatest extent possible. Location, building, and zone names do not apply to this project, but naming conventions must be matched. On-screen graphics must be clickable and route users to the item selected. Floor plan backgrounds used in graphics must match actual building layout and configuration. Naming of equipment in graphics must match naming used on Plans. Graphics and operability must be tied into the existing school-system-wide remote access system and must be fully compatible with the existing system.

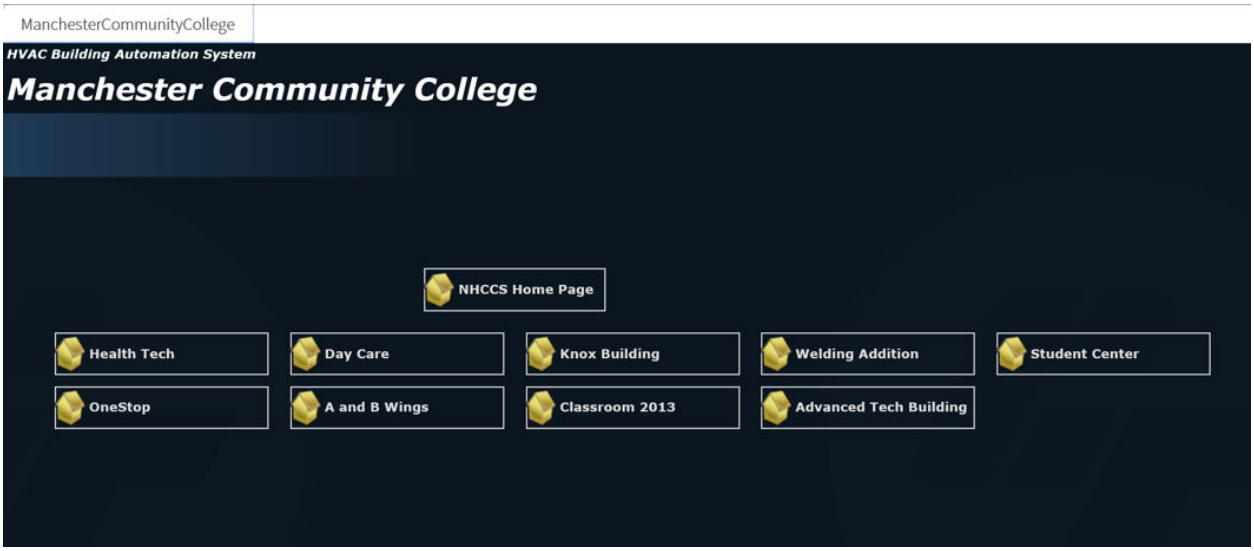

Figure A1. Campus home screen. Each rectangle represents a building on campus.

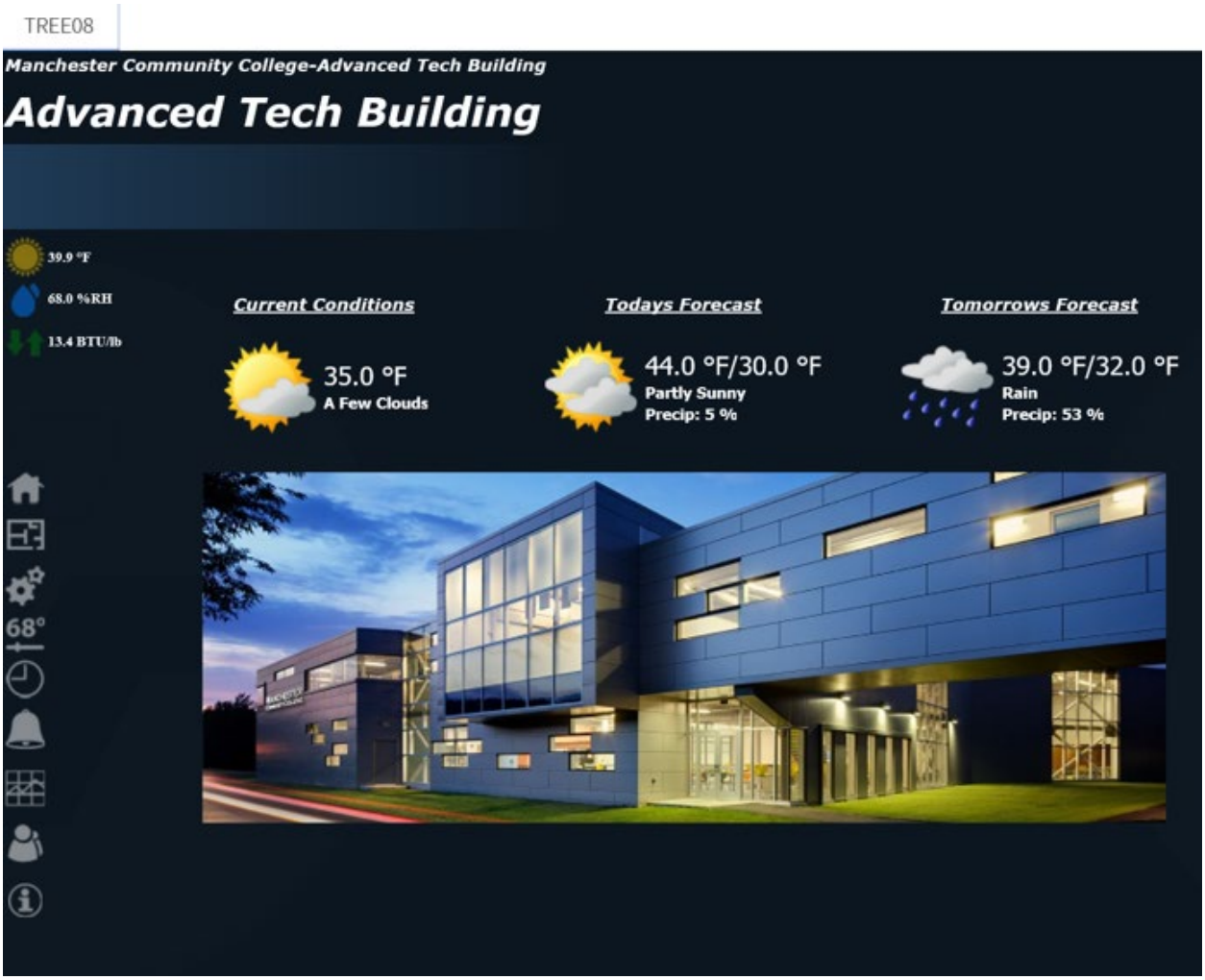

Figure A2. Building-specific screen. Accessed by clicking the building name shown in Figure A1.

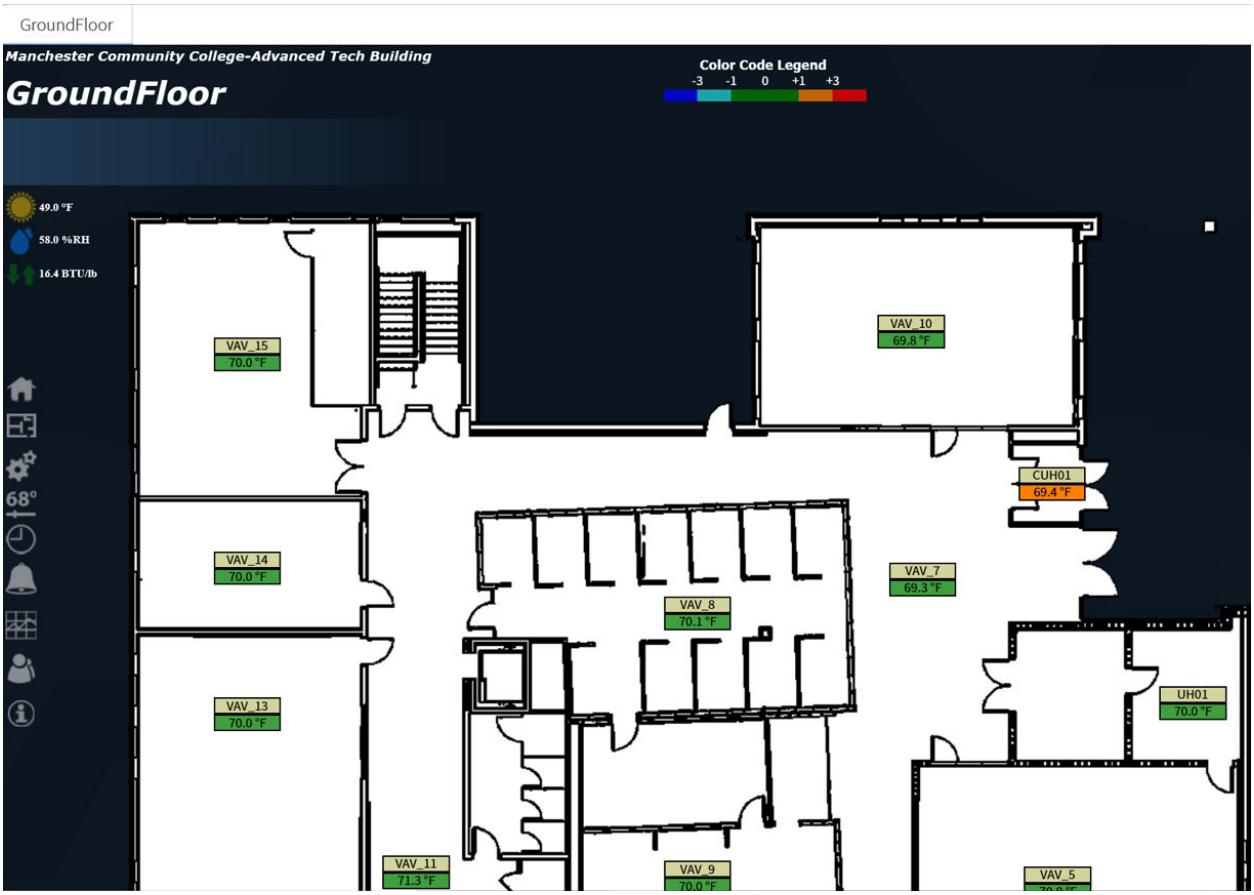

Figure A3. Floor plan. Includes equipment number of HVAC units serving spaces along with current space temperature. Space temperatures must be color-coded, with green indicating an acceptable temperature, as shown in the color code legend at the top of the graphics page.

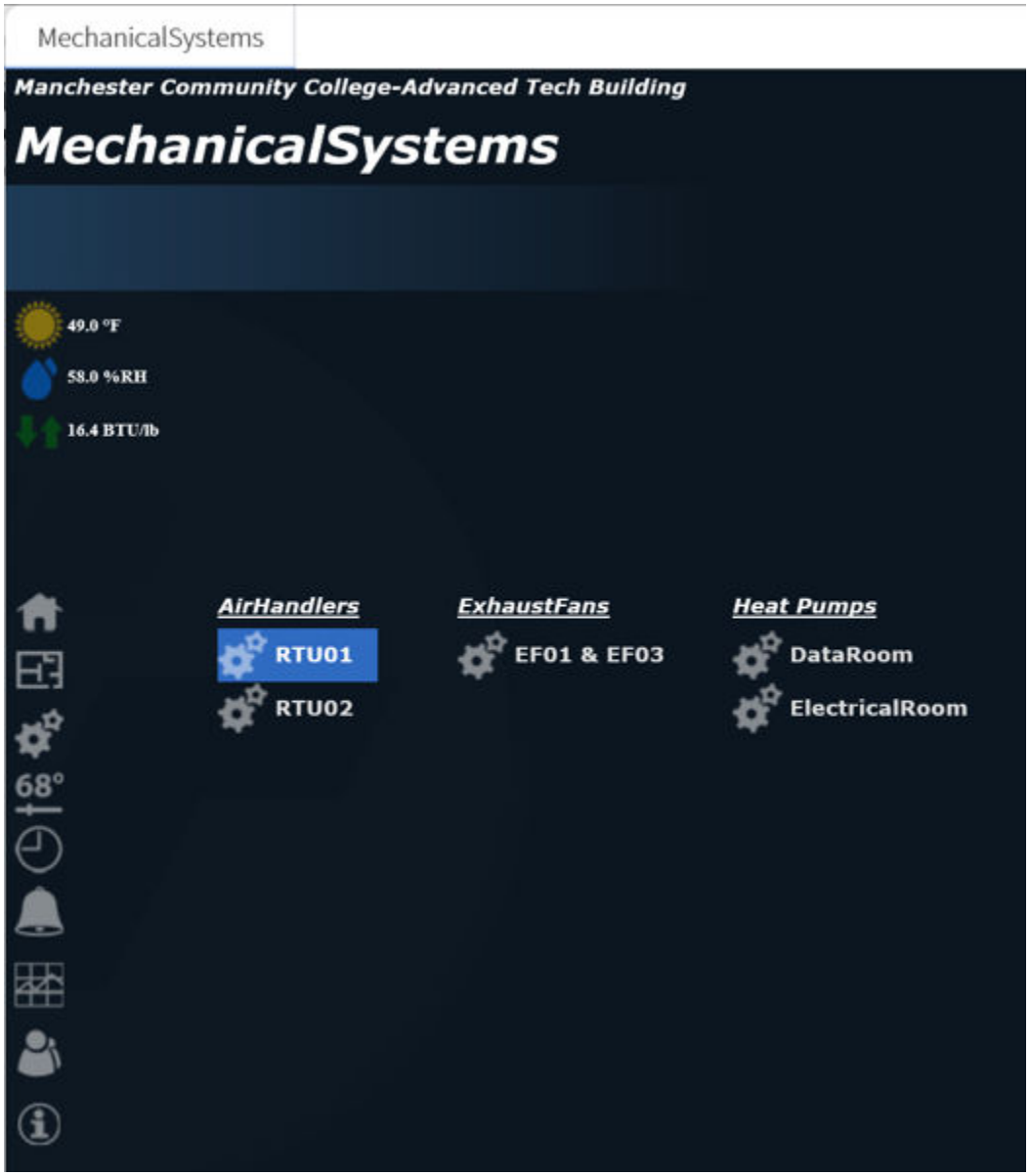

Figure A4. Mechanical systems screen for one building on campus. Must be organized by equipment type as shown in the sample graphic. Units must be clickable and must route user to the unit selected.

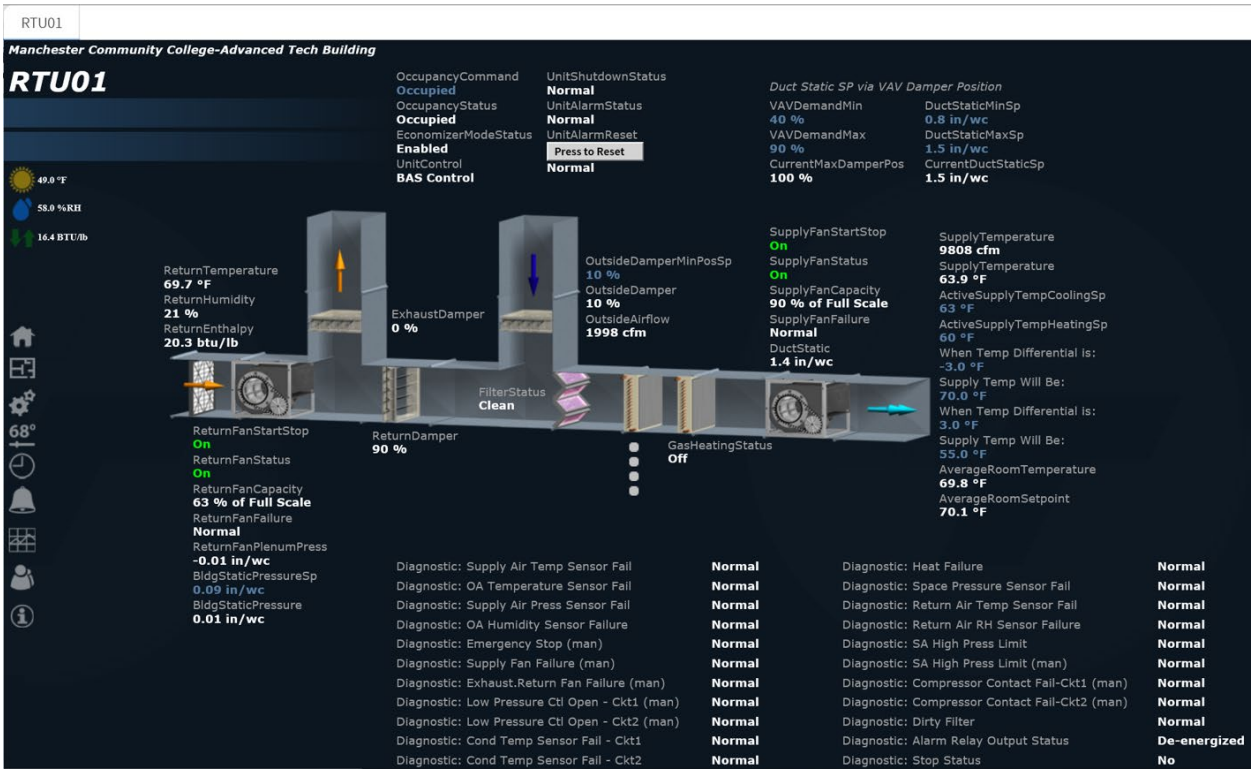

Figure A5. HVAC equipment/unit screen. Must display points indicated in controls sequences and points lists shown on the Drawings.

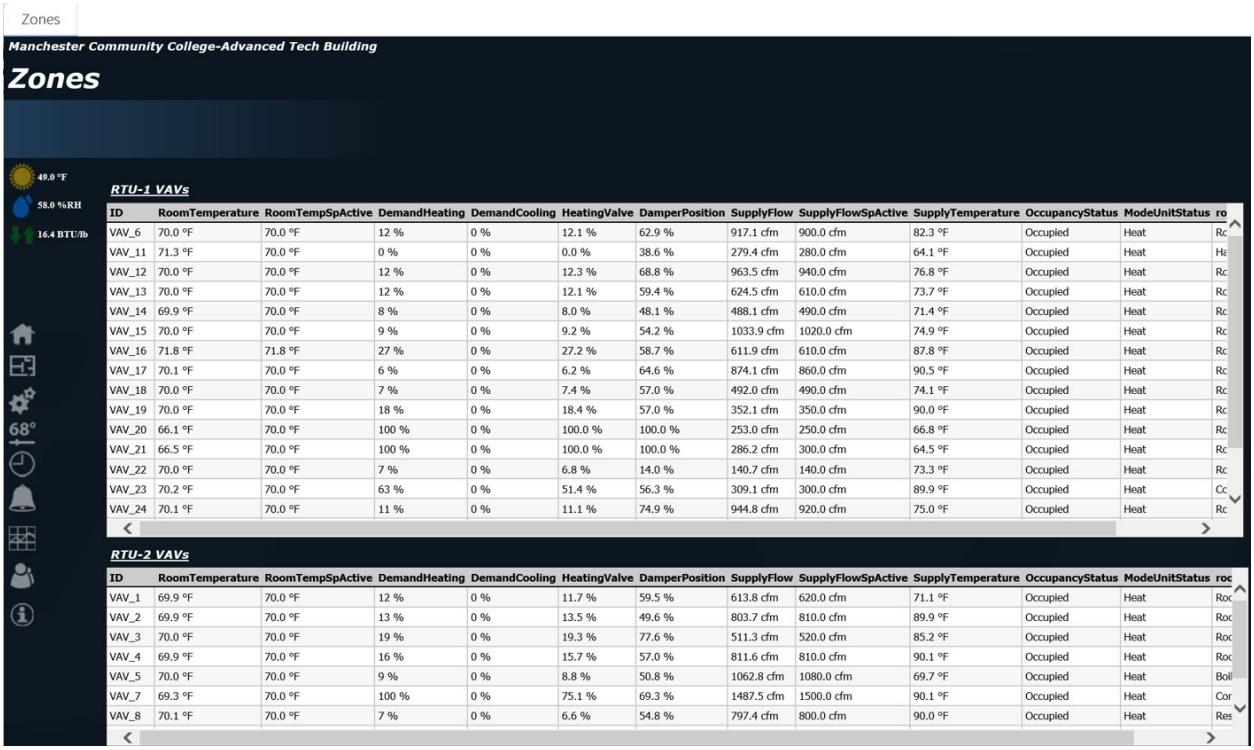

Figure A6. HVAC equipment zones screen. Must show all zone controls associated with one AHU.

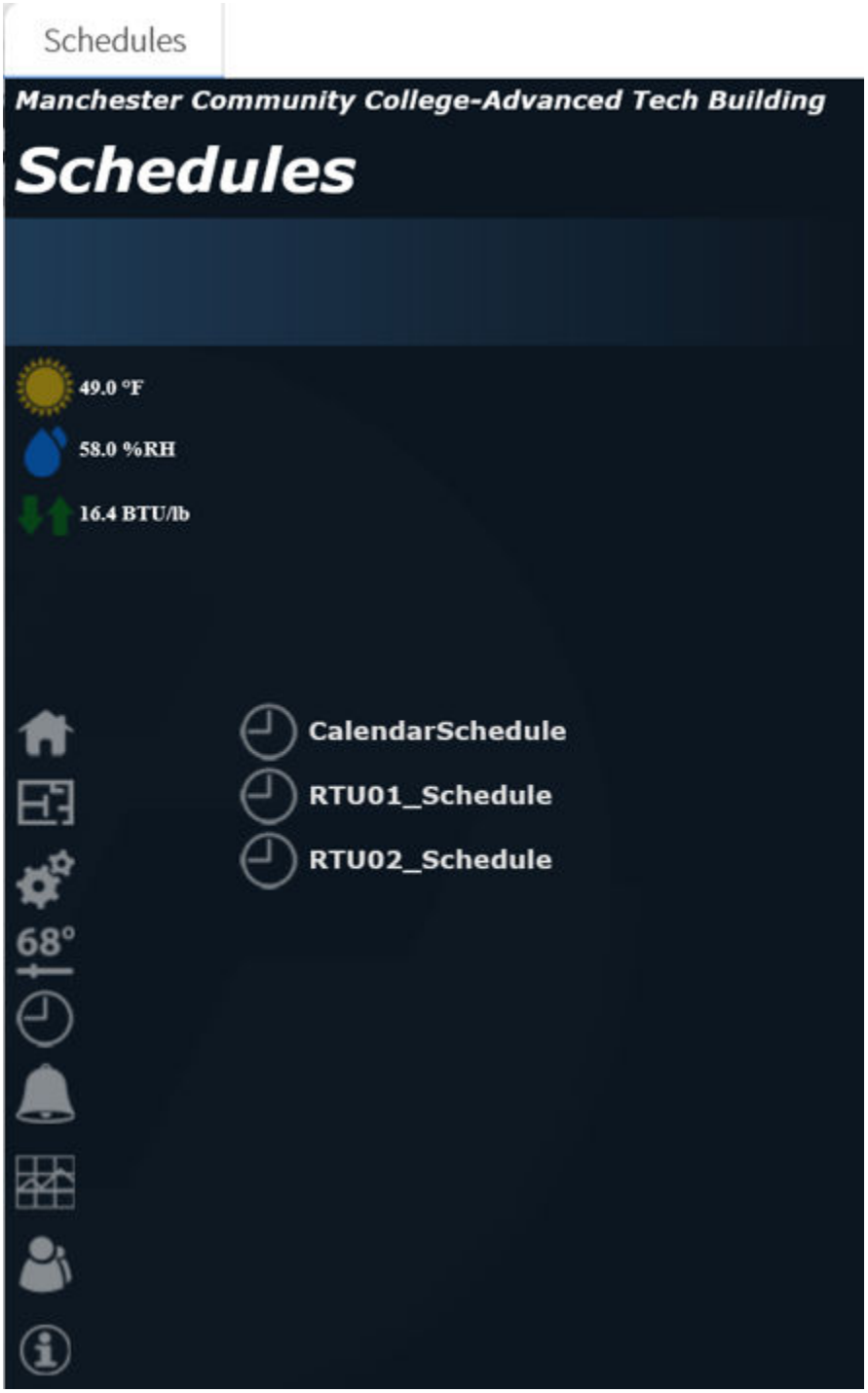

Figure A7. Schedules screen for one building on campus. Schedules must be editable via graphical user interface and must be organized by HVAC system.

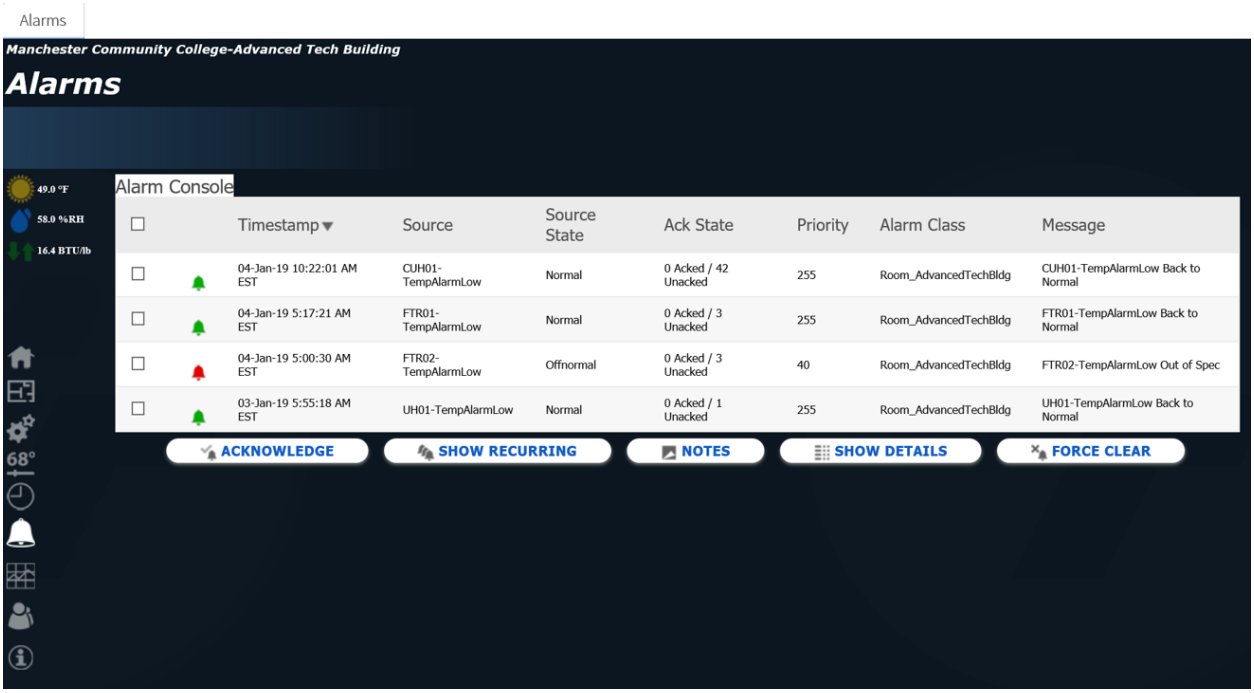

Figure A8. Alarms screen for one building on campus. Must indicate which are in an alarm condition via color-coding.

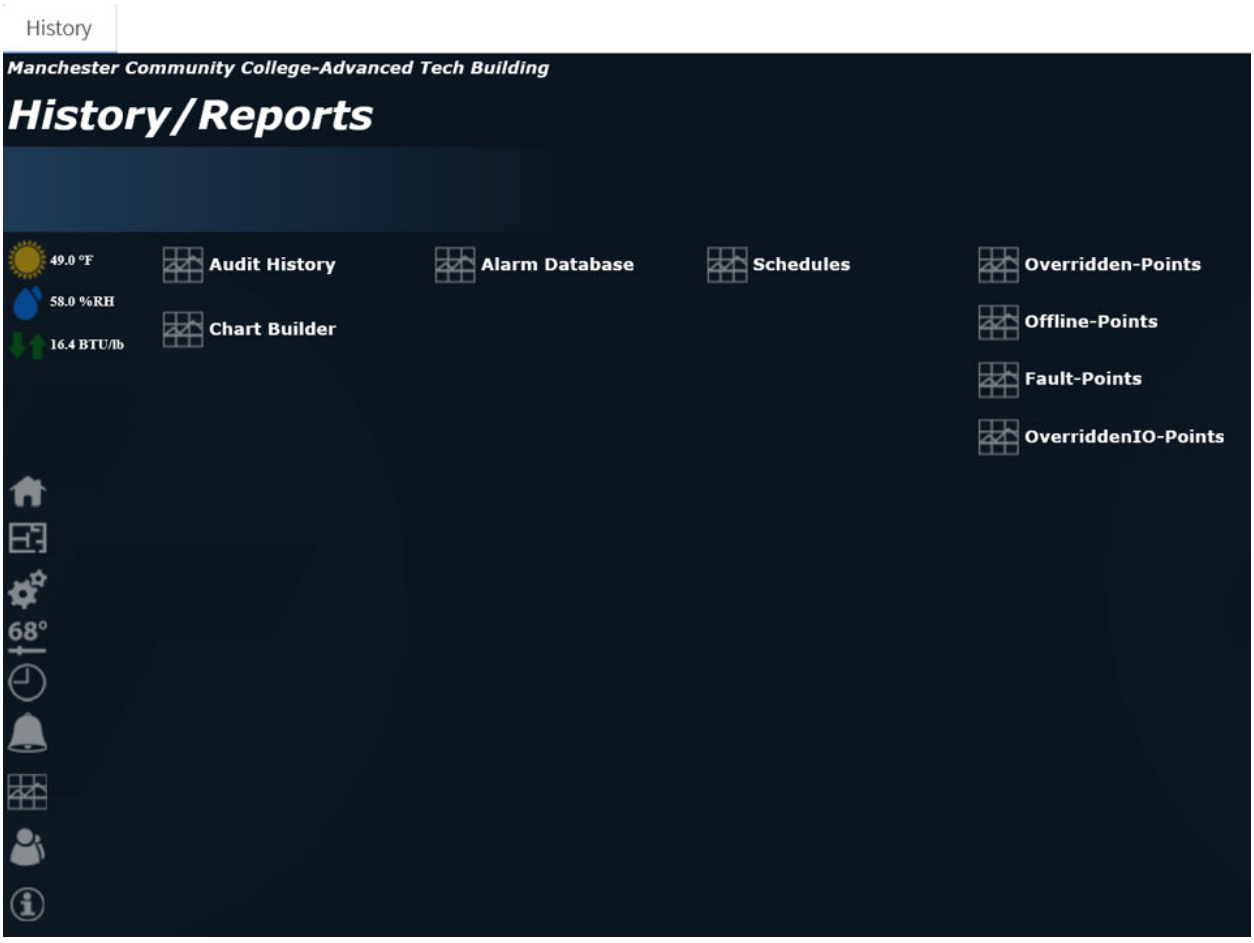

Figure A9. Trend logs for one building on campus. Must show historical trend data for all points indicated on the Drawings.

END OF SECTION 230900