TABLE OF CONTENTS
SECTION 230940 – HVAC INSTRUMENTATION AND CONTROLS

SECTION 230940 – HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems and equipment.

B. Manufacturers:

1. Acceptable manufacturers of electronic and DDC controls are Honeywell, Distec & Trane (Lynx-spring).
2. Other manufacturers will NOT be considered unless specifically requested in writing and specifically approved by the Engineer.

1.3 SCOPE

A. Contractor shall either expand existing Honeywell controls system located in adjacent building or provide new stand alone controls package with new head end by Distec or Trane. New control system shall convert all existing pneumatic control points to digital and control all new equipment shown on contract documents. A site visit is required to verify the scope of existing pneumatic control points.

B. Provide labor, materials, services, equipment and transportation necessary for complete and operational system of automatic temperature control and building management (i.e., DDC system), as indicated on Contract Drawings and specified herein, including, but NOT limited to, the following:

1. Controls for air systems including supply fans, heating coils, cooling coils, humidifiers, return fans, exhaust fans and dampers.
2. Controls for space heating systems including direct radiation, convectors, unit heaters.
3. Controls for heating hot water plant including water heater, circulating pumps and valves.
4. Controls for service hot water plant including water heater, circulating pumps and valves.
5. Heat recovery system controls.
6. Control piping.

7. Removal and/or relocation of existing thermostats to accommodate work, as required and as shown.
8. Checking, servicing, adjusting and putting in proper operating condition: existing controls (such as duct pressure controls and dampers) in systems affected by the Work, so that new and existing components work together to produce the required results.
9. Furnishing of automatic control valves and dampers, pressure sensors and sensor wells to be installed under Division 23.
10. Building Management System including:

    a. Control of mechanical systems
    b. Monitoring
    c. Alarm
    d. Energy Management
    e. Energy use reporting
    f. Calculation of data for custom reports
    g. Color graphics of floor plans and mechanical systems
    h. Totalization logs
    i. Historical trend logs

11. Fire dampers, volume dampers and control dampers.
12. Smoke dampers.
13. Combination fire/smoke dampers.
14. Sleeves, escutcheons, seals, waterproofing and similar devices.
15. Thermometers.
16. Pressure gauges.
17. Utility rebate motors for all applications, unless noted otherwise.
18. High efficiency motors for all applications unless noted otherwise.
19. Standard motors for all applications unless noted otherwise.
20. Motor starters.
21. Painting as required under Division 23.
22. Hangers, anchors, guides, bases and other supports.
23. Access panels and access doors.
24. System identification, including valve tags.
25. Noise and vibration control.
26. Seismic restraints, including equipment bolts and welding.
27. Cleaning, lubrication, testing, balancing and adjusting.
28. Coordination drawings.
29. Record drawings.
30. Operating and Maintenance Manuals.
31. Instructions.

1.4 SHOP DRAWINGS AND OTHER SUBMITTALS

A. Make preliminary submittal of two sets of Pneumatic and Electric control drawings to Engineer for review before shop drawings are submitted through normal channels. The purpose of this preliminary submittal is to save time. Include the following information:

1. Temperature control ranges
2. Spring pressure ranges
3. Transducer ranges
4. Method of control
5. Control devices selected
6. Description of operation

B. Submit, for review, shop drawings for each item of material, equipment and system component furnished or installed as part of the work of this Section. Shop drawing requirements are specified under SECTION 230010, GENERAL REQUIREMENTS FOR MECHANICAL WORK and under DIVISION 1.

C. Shop drawings shall include control layout and data on sensitivity, pressure ranges, temperature ranges, means of adjustment, means of calibration, spring ranges and other data necessary for review of each device, its function and its intended application.

D. Devices on shop drawings shall be identified by numbers and letters. These identifiers shall also be used in description of operation, in control layouts and on data sheets for ease in cross-referencing.

E. Shop drawings shall include motor efficiency data for three-phase motors 1 HP and larger.

F. Submit circuit coordination information for review by Engineer and Contractor, indicating circuit requirements by electrical panel, i.e., panel identification and maximum load of each circuit required for control system. Submittal will be returned indicating Engineer's final determination of panels and circuits to be used.

1. Furnish copy of final circuit determinations to DIVISION 26 Contractor, for use in preparing panel directories. Information on circuits shall include control component and area served.

G. Furnish certificate from manufacturer of control system that expansion hardware and software shall be available for next 10 years.

H. Furnish ASME certified test certificates for receiver tank on air compressor.

I. Furnish instruction manual for review. Manual shall describe function and operation of all control and management system components and shall include trouble-shooting and operating procedures. Manual shall be easily understood, for use by Owner's personnel; shall show the total integrated control system; and shall include:

1. System description.
2. Control devices, including number, system, service, location and normal position of each.
3. Information on sequencing of related devices.
4. Calibration charts and instructions.

J. Submit software manual to Owner for review. Software manual shall describe programming and testing, including:

1. System overview and detailed description of each software feature.
2. Instructions for user operation, including verifying status and errors, changing passwords, and initiating or disabling control programs.
3. Description of programming language including commands, editing and writing control programs, algorithms, printouts and logs, mathematical calculations and passwords.
4. Copies of application program software and documentation necessary for Owner to interpret program and make any changes desired.
5. Instructions for user programming or reprogramming any portion of DDC system including control programs, algorithms, mathematical equations, variables, setpoints, time periods, messages and other information necessary to load, alter, test and execute DDC system.
6. Reference summary sheets, which compare control programs with pertinent information about hardware and field wiring information.
7. Point identification including terminal number, symbol, engineering units and control program reference number.
8. Field information including DDC system hardware and locations, device type and function, electrical parameters and record drawing reference numbers.

K. Submit data summary forms to Owner for review. Forms shall define following information, for inclusion into DDC system, for each point in DDC system.

1. Description of each piece of equipment and the functions to be controlled.
2. For each DDC system function, a listing of digital and/or analog hardware required to interface DDC system to equipment.
3. Listing of digital and analog alarms.
4. Listing of DDC system application programs associated with each piece of equipment. This listing shall include control algorithms and mathematical equations and shall be in easy-to-understand English format.

L. Upon completion of project, submit for review pneumatic control and electric control shop drawings corrected for “as-built” conditions. Shop drawings shall include final pressure settings, spring ranges, temperature ranges, throttling ranges and temperature control settings. Three copies of accepted “record” shop drawings shall be furnished to Architect.

1.5 COORDINATION DRAWINGS

A. Before materials are purchased or work is begun, prepare Coordination Drawings showing size and location of mechanical pipes, ducts, equipment and appurtenances, relative to work of other trades.

B. Submit for review coordination drawings signed by following trades: sheet metal, plumbing, fire protection, electrical and other HVAC trades. Drawings shall be composite construction floor plans, developed and submitted electronically.

C. Preliminary coordination drawings shall be prepared as follows:

1. First: Sheet metal trade shall prepare coordination drawings, minimum ¼" = 1' scale, to be used as composite construction floor plans for coordination of trades. Plans shall show floor and ductwork layouts in detail, including ceiling heights, duct heights and sizes (including insulation), registers and diffusers, and light fixtures.
2. Second: As part of work of Division 21, fire protection trade shall draw fire protection piping, etc., on coordination drawings prepared by sheet metal trade.
3. Third: As part of Division 26, Electrical Work, electrical trade shall draw electrical distribution conduits, wires, panels and other electrical work, which must be coordinated with other trades; on coordination drawings which have been prepared by fire protection trade.
4. Fourth: As part of work on Division 23, plumbing trade shall draw waste piping, vent piping, water piping, risers and other plumbing work which must be coordinated with other trades; on coordination drawings which have been prepared by electrical trade.
5. Fifth: As part of work of Division 23, HVAC trades shall draw HVAC piping work which must be coordinated with other trades; on coordination drawings which have been prepared by plumbing trade.
6. Each trade shall use a different color code.

D. Coordination Meeting and Drawing Revisions:

1. Sixth: Contractor shall hold a coordination meeting with sheet metal, HVAC, fire protection, electrical and plumbing trades and shall resolve conflicts between trades. Coordination drawings are to assist in identifying trade conflicts.
2. Seventh: Sheet metal trade shall revise coordination drawings to reflect revisions to the various trade work (including sheet metal, HVAC, fire protection, electrical and plumbing trades), as determined by coordination meeting.
3. Eighth: Sheet metal, HVAC, fire protection, electrical and plumbing trades shall sign the revised coordination drawings as indication of their acceptance of the construction layout shown thereon.

E. Sheet metal trade shall submit the revised coordination drawings to Architect for review.

F. Coordination Drawings are for Contractor's and Engineer's use during construction and shall not be construed as replacing shop, "as-built" or record drawings required elsewhere in the Contract Documents.

1.6 CONTRACTOR QUALIFICATION REQUIREMENTS

A. Demonstrate capability to execute this Contract by submitting evidence of following:

1. Minimum of five years, actively engaged in the business of installing control and automation systems.
2. Manufacturer's approved service facilities, located within the area covered by the installing office.

B. As requested, submit catalog data and letters or certificates from Owners of other buildings in which similar control systems have operated successfully as intended.

1.7 SERVICES

A. Provide necessary service, adjusting and checking of control and management systems, at no additional cost to the Owner, during 12-month period of guarantee.

1. This shall include service required to correct space temperature alarms and equipment control problems which are the result of control component malfunctions.
2. This shall NOT include service required to correct failure of mechanical equipment being controlled.
3. This shall include full system checkout and calibration during the 12th month of guarantee period.

B. Furnish service contract for Owner's consideration, which continues systems' service beyond the guarantee period. This is NOT part of the Construction Contract and is an extra cost to the Owner, at Owner's option.

1.8 INSTRUCTION TRAINING

A. Competent technicians shall provide 8 hours of instruction to the Owner's personnel. Instructions shall include, but are NOT limited to, the following:

1. Familiarization with HVAC Control system, hardware and operation procedures.
2. Familiarization with Management System Hardware.
3. Use of management system.
4. Modifications of software packages.
5. Trouble-shooting and service procedures.

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM – GENERAL REQUIREMENTS

A. All equipment shall be by one manufacturer, insofar as possible. Unless specified otherwise, equipment shall be fully modulating and state-of-the-art.

B. Contract Drawings do NOT show every control device and every location. It shall be understood that Specifications are the primary guide to control requirements and that, unless specifically excluded, every piece of heating and cooling equipment shown on Contract Drawings requires controlling device.

C. Control system shall be complete in all respects including:

1. Room, insert and immersion thermostats and sensors.

2. PE and EP switches.
3. Transmitters.
4. Relays.
5. Valves.
6. Dampers.
7. Air compressor assembly and refrigerated air dryer.
8. Control panels.
9. Electronic analog sensors: temperature, humidity, pressure, flow and/or others as required.
10. Digital controllers.
11. Central monitoring terminal (CMT).
12. Transmission power supply.
13. Operators' terminal and printer.
14. Air piping.
15. Pneumatic control piping.
16. Control wiring.
17. Auxiliary devices and accessories.
18. Interface with fire alarm system.
19. Modem/telephone interface and associated software.

D. Electronic monitoring system shall be UL listed or ETL approved.

E. Insofar as possible:

1. Sequencing shall be accomplished by selection and application of proper spring ranges to damper operators and valve operators; pilot positioners shall NOT be used in lieu of proper spring range selection.
2. Ranges and sensitivities of master controllers shall be selected to eliminate need for submaster controllers.

F. Provide power and control wiring, conduit, junction boxes, fittings and other electrical appurtenances that are required for complete and operational control and monitoring systems; conform to electrical standards, codes and requirements specified under DIVISION 26, ELECTRICAL WORK. This work shall include:

1. Wiring of control and monitoring devices and circuits carrying voltages up to and including 120 Volt, unless otherwise indicated.
2. Wiring of 120 VAC power feeds to temperature control panels, CPU, digital controllers, printer and other control system equipment.
3. Wiring required for interfacing with building fire alarm, security and emergency generator systems; including wiring between DDC panels and fire alarm system panels.
4. Wiring of control system including wiring from sensors to panels, wiring from panels to CPU, and wiring from CPU to operator's terminal.
5. Wiring to "Auto" side of hand-off-auto switches on units being controlled as part of work of this Division.

6. Wiring of devices controlled as part of the work of this Division, whether furnished under this Division or another Division. Examples of devices include: alarm device, relay, solenoid valve, actuator and electro-mechanical device at control cabinet.
7. Wiring of devices providing control inputs, whether furnished under this Division or another Division. Examples of devices include: smoke detector contact; fire alarm relay contact; pressure, temperature, limit level and motion switches; PE switch and analog sensor.
8. Wiring from temperature control panel to terminal strips.
9. Wiring between panel terminal strips and field-mounted devices.
10. Wiring from modems and alarm dialers to telephone jacks. Coordinate with Owner's telephone contractor.

G. For bidding purposes, unless otherwise indicated, closest appropriate electrical panel shall be assumed to have circuit(s) available for control system use. Coordinate selection of circuits for control system use, by special submittal; refer to paragraph 1.4.F where mechanical equipment is designed to operate on standby power during utility outages, derive all control power for end devices and panels/CPU from a standby power source.

H. Control and monitoring devices that are part of an engineered smoke control system shall be provided with emergency power.

I. Power wiring installed and terminated as part of the work of DIVISION 26, ELECTRICAL WORK, shall include:

1. Wiring of devices and circuits carrying voltages GREATER than 120 Volts, unless otherwise indicated.
2. Wiring of power feeds to disconnects, starters and electric motors.
3. Installation of, and wiring of line power to, fused disconnects for each air compressor.
4. Wiring from disconnects to equipment motor starters.
5. Wiring from equipment motor starters to equipment motors.

2.2 TRANSMISSION NETWORK

A. Automatic system shall have multi-drop digital transmission network that provides communication link between operator's terminal and all DDC panels.

B. System shall have error checking feature to ensure signal reliability and shall identify signal transmission network failures. System shall ensure signal quality and strength. System shall support multiple multi-drop trunks.

1. All multi-drop trunks shall be interfaced to the system via standard EIA interface.
2. When used with modems, multi-drop trunk shall interface to unconditioned voice-band 3002 telephone lines for remote building tie-in to automation system.

C. Transmission network shall be run in conduit or shall be shielded cable. Wiring shall NOT be run in same conduit with fire alarm, security, lighting, building power or other dedicated systems.

D. Transmission network speed shall be minimum 9600 baud rate.

2.3 CONTROL DAMPERS

A. Provide control dampers for each fan system, to allow effective modulation or close-off of air flow as required.

1. Dampers shall be low leakage design, with seals along both edges and ends of damper blades to provide tight closure. Air leakage of damper when in closed position shall NOT exceed 1% of system design volume at 1" w.g. differential pressure.
2. Dampers shall be sized for design velocities of 1500 fpm through free area of damper at maximum system air flows.
3. Two-position dampers shall have parallel blade linkage; modulating dampers shall have opposed blade linkage. Dampers shall be arranged for normally open or normally closed operation, as required. Linkage shall be serviceable without removal of entire damper.
4. Damper construction shall be suitable for damper operation at maximum fan pressure, without failure, binding or distortion.

B. Damper frames shall be either galvanized steel or aluminum, constructed to facilitate field assembly. Frames shall have openings or mounting clips which allow secure fastening of frame to surrounding ductwork, duct collar or fan housing.

C. Damper blades shall be either galvanized steel or aluminum, with maximum blade length of 48" in any section. Blades shall have suitable bearings for smooth operation and shall be interconnected to provide unison operation.

D. Provide stiffening or bracing for frame sections over 48" high.

E. Outdoor air dampers shall have separate minimum and maximum sections.

F. Provide insulated damper blades on outside air plenums, dog house louvers, etc., that do not have ductwork connected.

2.4 DAMPER ACTUATORS

A. Motor actuators shall have non-overloading motors, and shall be direct drive by Belimo or acceptable equivalent. Actuators shall have moisture- and corrosion-resistant construction suitable for the environment in which they are installed.

B. Actuator sizing and quantity shall be determined by control manufacturer:

1. As needed to meet system requirements.
2. As needed to provide sufficient power for smooth modulation over entire range.
3. As needed to be able to open or close damper without binding or damage, at pressure differential up to 4" w.g. for low pressure systems and up to 8" w.g. for medium and high pressure systems.

C. Provide actuator for each damper over four feet in length or height.

D. Each actuator shall be matched to the type of analog output available from the controller and shall have a matching control range.

E. Assembly shall include necessary mounting hardware and brackets.

F. Motors at outdoor air ducts (intake and exhaust) and motors interlocked with them shall have a power-fail safety device which return motors to their normal position.

G. Where required, provide end switches and/or feedback potentiometer to report actuator position.

H. Damper operators for packaged terminal air control devices are specified under Division 23.

I. For terminal units: Control valve pressure drops should be minimum of 10 feet, may be up to 25% of pump head on small systems and may be up to 15-20% of pump head on large systems.

J. For mechanical room units (close to pump), when only system piping is within mechanical room: Control valve pressure drops may be lower to limit pump head (2-12 foot range, or 1-5 psig). If total system head is greater than 45 feet, use 50% of this head for valves near the pump (e.g. 22 ft) and 25% for furthest valves (e.g. 11 ft).

K. If system uses only 3-way control valves: Control valve pressure drop is not as critical and may be lower than for 2-way valve system.

L. Check proper close-off pressure with Engineer or Principal.

M. You should always allow for at least a 10 ft control valve drop when sizing the pump.

2.5 AUTOMATIC CONTROL VALVES - GLOBE/PLUG TYPE

A. Provide automatic temperature control valves for services as indicated on Contract Drawings. Valves shall be normally open, normally closed or mixing type, as required. Unless otherwise noted, valves shall be as follows:

1. Valves 2" and smaller: Globe valve, 250# WOG, 150# WSP, bronze body, screwed ends.
2. Valves 2-1/2" and larger: ANSI Class 150, steel body, bronze trim, flanged ends.

B. Valve design shall allow disassembly of valve top, inspection and replacement of packing without system shutdown or valve body removal.

C. Provide following accessories:

1. Valve stem packing: low friction, tight sealing, of material and pressure rating suitable for service.
2. Valve stems of polished stainless steel or Monel, for valves 2-/12" and larger.

3. Valve actuators: suitable and sized for closing against system differential pressure; with proper spring ranges to facilitate sequencing application (pneumatic).

D. Provide hot water radiation valves:

1. Of compact modulating design, bronze or forged brass body, with ports sized to provide accurate control under any load condition.
2. With valve tops sized to fit within radiation enclosures.
3. With maximum hot water pressure drop through valve of 2 psig.

E. Provide hot water coil valves & chilled water coil valves:

1. In general, valves shall be two-way modulating type, equal percentage valves with throttling plug, selected to have pressure drop between 4 psig and 6 psig at maximum design flow.
2. Where indicated, valve shall be three-way modulating type, equal percentage valve with throttling plug, selected to have pressure drop between 2 psig and 5 psig at maximum design flow.
3. Valves shall have close-off rating suitable for minimum differential pressure of 60 psig. Insofar as possible, valves on same pump system shall have approximately same pressure drop. Higher pressure drops are permitted on valves nearest to pump (up to 50% of system pressure drop on systems with total pump head over 45 feet).
4. Hot water coil valves shall be normally open to coil. Operators shall be coordinated with cooling coil valves so that both coils CANNOT be activated simultaneously.
5. Chilled water coil valves shall be normally closed to coil. Operators shall be coordinated with heating coil valves so that both coils CANNOT be activated simultaneously.

F. Reheat water valves shall be normally closed to coil or shall be floating control type which remains at last position.

2.6 ROOM AND DUCT HYGROSTATS

A. Hygrostats shall be gradual acting with ambient temperature compensation. Hygrostat shall have highly sensitive hygroscopic element, with adjustable setpoint and sensitivity.

1. Sensitivity shall be adjustable from 1/4 to 4 psi per 1% RH.
2. Control range shall be 20 to 80% RH with 1/4% RH response.

2.7 THERMOMETERS

A. Unless otherwise specified, local thermometers for central air system shall be provided under Division 23.

2.8 ELECTRONIC TRANSMITTERS AND SENSORS

A. Electronic Temperature Transmitters: shall be solid state; RTD, thermistor or IC type which transmit electric analog signal to DDC panel; shall have proper range and accessories to transmit temperature value to DDC panel with accuracy of +/-1°F; shall be field calibrated, wired between point of sensing and DDC panel.

B. Space Temperature Sensors: shall be thermistor RTD or IC type; with cover of brushed aluminum or as accepted by Architect; with locking vandal-resistant guards keyed alike.

C. Sensors for outdoor shall have suitable radiation shield and weatherproof enclosure. Outdoor air temperature sensor shall be RTD type with platinum element.

D. Sensors to measure discharge and return air duct temperatures shall use single point sensing. Sensor to measure mixed air temperatures shall be averaging type with minimum 20-foot capillary element or averaging probe type.

E. Pipe Immersion Temperature Sensors: shall have stainless steel immersion well and accessories. When installed on inlet and outlet of heat exchanger, sensors shall be selected from the same manufacturing run, certified to read within +/-0.1°F of each other.

F. Space or Duct Relative Humidity Sensors: shall be accurate to +/-3% when compared to accurate reference psychrometer, from 20% RH to 80% RH.

G. Low Pressure Transmitters for liquid differential pressure:

1. Transmitters shall have accuracy of +/-0.25%; shall be capable of withstanding system pressure applied to one port with no pressure on other port; shall be Setra #228, Viatran #323, Mamac #PR-284 or acceptable equivalent by Rosemont or Omega.
2. Provide three-valve manifold to simplify calibration. Provide mounting suitable to relieve stress on tubing and sensing transducer.
3. For differential pressures greater than 1.5 psi and low static head, Robinson-Halpern #150 is acceptable substitution.

H. Analog sensors shall be compatible with systems specified, carefully selected for the required span.

I. All sensor wiring - analog or digital, input or output - shall be capable of sharing single conduit runs without affecting signal performance. Sensor wiring shall be capable of sharing single conduit runs with switched 120 VAC or 240 VAC. If this is NOT possible, provide separate conduits for sensor wiring, to ensure signal integrity.

2.9 SMOKE DETECTION

A. As part of work of DIVISION 26, ELECTRICAL WORK: Furnish two smoke detectors for each air system rated above 2,000 cfm and for each air system so indicated on Contract Drawings.

B. Installation of smoke detectors in the air systems, (first) one on discharge side of supply fan and (second) one in return/exhaust airstream, shall be done as part of work of SECTION 230880, BASIC MATERIALS - AIR DISTRIBUTION.

C. As part of work of this Section, provide wiring from smoke detectors to DDC system so that, when a detector serving a particular system senses smoke, DDC system shall:

1. Indicate alarm condition at DDC system console.
2. Stop that system's supply, return and exhaust fans.
3. Close that system's outside air intake and exhaust dampers.
4. For systems with supply air quantity of 15,000 cfm or more: Close that system's return air damper and discharge fire/smoke damper.

D. Detector installation and control action shall be strictly in accordance with NFPA 90A.

2.10 CONTROL PANELS

A. Control panels shall be fully enclosed, all metal construction. Panels shall have hinged door with full piano hinges or heavy duty concealed hinges, with locking latch or bolt-on cover plate and with work light and switch. All panel locks shall be common keyed. Panels shall be finished with two coats of enamel paint.

B. Indicating devices and manual adjustment devices required for routing operation of system shall be located on panel door or cover plate. Other devices shall be located on sub-panel within panel.

C. Panels shall have ample room for control device mounting and wiring.

D. Panels shall house control apparatus, relays, I-P transducers, EP and PE switches, gauges, and other items required to implement the control sequence.

E. Panel shall display: discharge air temperature, return air temperature, mixed air temperature, outdoor air temperature, and alarm lights.

2.11 SYSTEM SOFTWARE AND GRAPHICS

A. Provide software required for efficient operation of functions required. Software shall be modular in design with flexibility in expansion and revision of the system. Software shall include, as a minimum:

1. Complete database entry.
2. Configuration of application programs to provide the sequence of operation indicated.
3. Graphics of each system as shown on the I/O Summary Table.
4. Alarm limits and alarm messages for critical and non-critical alarms.
5. Configuration of reports and point summaries indicted.
6. Capability for graphic programming.

B. Software package shall display graphically, in different colors, the following system information:

1. General area maps, showing locations of controlled buildings in relation to local landmarks.
2. Floor plan maps, showing heating and cooling zones throughout the buildings. Colors shall provide visual display of temperature relative to zone's respective setpoints. Colors shall be updated dynamically as the zones' comfort conditions change. Setpoint adjustment and color band displays shall be provided as specified in paragraph 3.02.D.5 "Setpoints".
3. Mechanical system graphics, showing the type of mechanical system components serving each zone, by use of pictorial representation of components. Graphic shall provide current status of I/O points being controlled, as applicable to each piece of equipment, including analog readouts in appropriate engineering units, at appropriate locations on the graphic.

C. Each category of software shall consist of interactive software modules. Each module shall have an associated priority level and shall execute as determined by the program controller as defined in the real-time operating system.

D. Software package shall allow receipt of alarms and messages while in a functional mode other than energy management, i.e., incoming alarms shall be displayed while the operator is in word processing, spreadsheet or other operating mode. System must automatically: switch from non-energy management mode, respond to an alarm, and return to the exact position left in the previous functional mode.

E. Operator must be able to communicate and direct control functions through the use of two-button "mouse" operator interface to monitor and control functions and sequences within the system.

F. System shall operate on a "System" Format basis, regardless of the manner or hardware configuration in which the data is acquired. A "system" shall consist of a logical grouping of data points, related to a piece of mechanical equipment, an energy distribution system, or an architectural area. Output displays, logs of a point and logs of a group of points shall contain following information:

1. Graphic presentation of the system
2. User name of point
3. Point descriptor
4. Current value/status
5. Associated engineering units
6. Alarm description

G. System shall have capability to display setpoints and variables for each zone graphically. System shall allow setpoints to be changed in the graphics mode. System shall update the variable display continuously.

H. DDC/EMS shall be programmed to provide separate color graphic for:

1. Each piece of equipment being monitored or controlled
2. Each floor and zone being controlled
3. Each schedule
4. Each trend
5. Each report

I. Operator sign-on shall require as a signable password. System shall have up to 32 passwords, each of which may be one of six levels of system access.

J. Power Failure/Automatic Restart at the Control Module

1. Power failure shall cause the control module to go into an orderly shutdown with no loss of program memory.
2. Upon resumption of power, control module shall automatically restart and shall print out the time and date of power failure and of power restoration, at the respective central site system.
3. Restart program shall automatically restart affected field equipment. Operator shall be able to define an automatic power-up time delay for each piece of equipment under control.

K. Changes to database and program shall be done using standard procedures and shall be capable of being done while the system is on-line and operational. System shall allow changes to be made at the local site through a portable computer. System shall permit the operator to perform the following:

1. Add and delete points.
2. Modify point parameters.

L. Graphics software shall permit the easy construction of infinitely variable shapes and sizes through the use of the mouse pointing device. Graphics software shall be fully implemented and operational to accomplish the following:

1. Create a new graphic picture
2. Modify a portion of a graphic picture
3. Delete a graphic picture
4. Delete a portion of a graphic picture
5. Call up a graphic picture
6. Cancel the display of a graphic picture
7. Assign conditions which automatically initiate the display
8. Overlay alphanumerics and graphics
9. Save the graphic picture
10. Display the latest process data fully integrated with the graphic display

M. System shall be able to trend and to display, either numerically or graphically: each analog point, each digital point and each calculated point. System shall be able to display graphically simultaneously two trended points within a module function block showing the most recent sixty samples. Each field module shall be capable of storing the more recent 288 samples for every hardware point in the module, with sample intervals as small as one second. Operator

shall be able to select and to display graphically the trends of up to four points simultaneously on a single trend graph.

N. System shall provide runtime information for digital output points and for digital input points, for modules, upon operator command. Maximum runtime limits shall be operator definable and shall be capable of automatically issuing a printed message when the runtime maximum is exceeded. Operator shall be able to reset the runtime accumulator. Runtime hours and start time date shall be retained in non-volatile module memory.

O. System shall allow receipt of alarms and messages while in a functional mode other than energy management, i.e., incoming alarms shall be displayed while the operator is using another mode such as word processing and shall allow the operator to automatically return to word processing after the alarm is received.

1. System shall distinguish between alarms and messages, with alarms having a higher priority.
2. System shall be capable of calling up to three different remote locations to deliver an alarm or message. Operator shall determine if alarms or messages are to be based on temperature limit, status, or off-normal reporting.
3. Text for operator alarm and messages shall be operator definable. System shall be capable of storing minimum 100 messages, each of different length.

P. Field modules shall be capable of calling the central processing unit during off-peak phone rate hours to automatically upload current and accumulated data. System shall be capable of reporting and archiving the following information:

1. Outdoor air temperature history and degree-day history.
2. Electric demand and usage history.
3. All trended points.
4. All alarms and messages.
5. Equipment runtime information.

Q. System shall be capable of reporting following information, for which archiving is not applicable:

1. All points summary.
2. Building operating schedules.
3. Printout of graphic screen.

R. Provide DOS-based text editor program which allows operator to create custom report and logging formats. Custom report generation shall be able to be initiated: manually, based on field occurrence, based on time and any combination. Operator shall be able to have the system:

1. Report the desired point data from the field.
2. Insert the data in custom report format.
3. Store the report on disk.
4. Print out the report on the system printer and/or a remote printer.

S. Provide following application software for optimizing energy consumption while maintaining occupant comfort:

1. Scheduled start/stop (OSS)
2. Optimum start/stop (OSS) and optimum enable/disable (OED)
3. Source temperature optimization (STO)
4. Demand limiting (DL)
5. Day/night setback (DNS)
6. Timed local override (TLO)
7. Direct digital unitary zone control

2.12 ENERGY MANAGEMENT ROUTINES

A. Automation system shall include software for energy management applications. Application routines shall be compatible with, and capable of simultaneous use in, system. Use of any routine shall NOT cause other software to malfunction.

B. Provide the following application routines for energy management:

1. Time of Day
2. Remote Reset
3. Start/Stop Time Optimization
4. Warmup/Cooldown Cycles
5. Timed Override
6. Major system performance reporting including:
    a. Heat Btu/Degree Day
    b. Cool KW per ton for each system
    c. Daily, weekly and monthly totalization of heating and cooling energy

2.13 SEQUENCE OF OPERATION: MAKE-UP AIR UNIT

A. Occupied Cycle:

1. Outdoor air intake damper shall open. Then, supply fan and heat recovery system shall start and run continuously, subject to end switch on the actuators for outdoor air damper.
2. If supply air temperature falls below setpoint, heating coil hot water control valve shall modulate open to bring supply air temperature back to setpoint.
3. If supply air temperature rises above setpoint, heating valve shall close and cooling coil chilled water control valve shall modulate open to bring supply air temperature back to setpoint.

4. Supply air setpoint shall be determined by the following outdoor air reset schedule:

Outdoor Air Temperature	***Supply Air Temperature***
0°F	70°F
75°F and above	70°F

B. Smoke Detection:

1. When smoke is detected by supply or outdoor air smoke detectors (provided under DIVISION 26, ELECTRICAL WORK) , following sequence shall occur:

   a. Supply and exhaust fans shall stop.
   b. Outdoor air damper shall close.
   c. Alarm condition shall be reported at operator terminal in hard copy.

2. Provide tie-in to auxiliary contacts supplied with fire alarm system; refer to DIVISION 26, ELECTRICAL WORK. Contacts shall annunciate at DDC system's input/output devices.

C. Fan shutdown for freeze protection and smoke detection shall be carried out directly through hardwiring to fan starters.

2.14 SEQUENCE OF OPERATION: FAN COIL UNITS - HEATING/COOLING

A. Temperature controls shall consist of independent DDC terminal control units. As part of work of this Section, provide a relay mounted in the fan coil unit enclosure to allow on/off operation of unit. FCU power wiring to relay shall be by DIVISION 26, ELECTRICALW ORK; control wiring shall be provided as part of the work of this Section.

B. A single temperature sensor and unoccupied override control shall be provided for rooms with multiple fan coil units. Temperature sensor shall be provided with local setpoint control.

2.15

2.15 SEQUENCE OF OPERATION: PUMPS

A. DDC system shall allow operating personnel to select which pumps shall run first and which shall run second, to provide even wear on pumps. DDC system shall allow revision of sequencing as often as desirable or according to pre-selected schedule. Switchover of lead pump shall be scheduled based on runtime, with a default switchover runtime of 84 hours.

B. Pump status information shall originate from dry contacts of pump differential pressure switches provided under this Division, or from flow meter.

C. Hot Water Circulator Pumps:

1. DDC system shall start lead pump when outside air temperature falls below 60°F and system is in occupied mode.
2. In unoccupied mode, pumps shall be started and stopped based on DDC zone temperature sensors or upon DDC system input indicating that one of the fan coil units is in the override mode.
3. DDC system shall indicate heating pump failure alarm and shall start lag pump:
   a. If outside air temperature is below 55°F and hot water supply temperature is below 100°F.
   b. If pump status contacts indicate a "no-flow" condition.

Outdoor Temperature	***Supply Water Temperature***
0°F	180°F
60°F	130°F

D. Provide flow meter and matched temperature sensors in high temperature hot water circuit. Provide software to calculate BTUs per month and average BTUs per degree-day for the month.

2.16 SEQUENCE OF OPERATION: PERIMETER RADIATION

A. Day-night room thermostats shall modulate automatic valves in radiation piping, to maintain normal day temperature. During unoccupied periods, thermostats shall maintain lower temperature (night) setpoint.

B. Under morning warm-up cycle, occupied/unoccupied thermostat shall go to occupied setpoint and heating valve shall go to 100% open position, until space temperature is within 3°F of occupied setpoint temperature.

C. In areas served by both VAV air system and perimeter radiation, radiation shall be under control by thermostat which also controls VAV terminal boxes. Radiation valves shall be sequenced so that these two heat sources will work in unison.

2.17 SEQUENCE OF OPERATION: CONVECTORS

A. Dual temperature thermostat shall modulate hot water valve to maintain occupied and unoccupied temperatures.

2.18 SEQUENCE OF OPERATION: UNIT HEATERS

A. Electric single-temperature line voltage thermostat shall operate unit heater fan and heating coil, as needed to maintain space temperature of 60-65°F.

B. In elevator machine room, dual purpose thermostat may be used if thermostat has independent settings that will start exhaust fan upon sensing space temperature over 80°F.

C. Strap-on aquastat shall prevent fan operation if hot water temperature falls below 85°F.

2.19 SEQUENCE OF OPERATION: CABINET UNIT HEATERS

A. Dual temperature thermostat shall modulate hot water valve to maintain desired occupied and unoccupied temperatures.

B. Strap-on thermostat shall prevent fan operation if hot water or steam is NOT available.

2.20 OPERATION: DOMESTIC HOT WATER HEATER

A. Modulate primary high temperature hot water (HTHW) flow to the domestic hot water heat exchanger to maintain setpoint in storage tank. When tank sensor calls for heat, start recirculation pump. When tank sensor is satisfied, stop pump and primary HTHW flow.

B. Totalize monthly BTUs used.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate with work of DIVISION 26, ELECTRICAL WORK, and work of other Sections of this Division for following:

1. Smoke alarms for air systems, indicated from dry contact relays at local temperature control panels. Relays shall be provided under DIVISION 26, ELECTRICAL WORK.
2. Power to control panels.

B. Provide self-tuning control loops or readjust hardware and software as necessary to compensate for equipment interactions and extremes of outdoor conditions while preserving efficiency and comfort.

3.2 INSTALLATION OF CONTROL WIRING

A. Control troughing and conduit shall be properly supported and anchored; shall be installed in harmony with building lines; and shall NOT interfere with maintenance, service or replacement of other equipment, conduit or piping.

B. Wiring and cables in mechanical equipment spaces or above hung ceilings shall be supported independently from pipes, conduits and ducts of other trades.

C. Wiring, cables and piping shall NOT be dropped over lighting fixtures nor allowed to lay directly on top of ceiling panels or panel support members.

D. Control cable to VFD speed input shall be shielded and shall be installed without excess cable so that electrical noise shall be minimized.

E. Wiring shall be concealed in occupied spaces and protected by conduit where exposed in mechanical rooms, floor-to-floor risers, drops to wall sensor boxes or where subject to damage.

3.3 INSTALLATION OF EQUIPMENT, SENSORS AND VALVES

A. Thermostats shall be mounted 6 feet above finished floors in corridors or stairs; elsewhere, they shall be mounted 66 inches above finished floors. Exact locations shall be coordinated with adjacent light switches and other wall-mounted devices. Space temperature sensor shall be mounted adjacent to thermostat.

B. Control valves shall be installed in true vertical position with operator on top.

3.4 ADJUSTMENT AND CALIBRATION

A. Calibrate, test and adjust controls and control system including pneumatic and electric controls, thermostats, valves, damper motors and relays until system is properly adjusted and ready for use. Management system's hardware and software shall be completely checked, test run and modified as required.

B. Be present for functional tests on systems. Before Engineer is asked to witness functional tests, ensure that:

1. Entire control and management system is complete.
2. Controls are calibrated.
3. Controlled devices and equipment have been physically inspected and checked to ensure that these terminal devices are under proper control and working smoothly over their entire range of operation.

C. Adjustment procedure shall include following steps:

1. Preliminary setup and calibration, as specified and as shown on shop drawings.
2. Physical checkout of all components for completeness and accuracy, simultaneously with system adjustment procedure outlined in DIVISION 23, TESTING, ADJUSTING AND BALANCING, together with any required modifications.
3. Review of system with Engineer.
4. Functional tests for Owner's benefit, instruction and acceptance.
5. Review of problems with Owner, rechecking adjustments and calibration as required. Review, rechecking and calibration shall occur NOT less than 30 days nor more than 60 days after systems have been in full operation.

D. Control and Management systems shall NOT be considered complete nor acceptable until:

1. All conditions of Sequence of Operation have been attained.
2. All temperatures are maintained within specified limits under all operating conditions.
3. All system damper leakage is controlled within specified limits.

E. Where pneumatic-actuated damper operators are required, provide current-to-pneumatic (I/P) transducers mounted within airflow control centers or DDC panels.

F. As part of work of this Section, provide calibration and adjustment of airflow control components and be responsible for setting control setpoints, operating sequences, and alarming systems contained within airflow control centers, to produce following overall system performance. Coordinate with DIVISION 23, TESTING, ADJUSTING AND BALANCING.

1. Constant static pressure control within 5% of duct static setpoint without any hunting or cycling.

3.5 DEMOLITION: IMPACT ON EXISTING SYSTEMS

A. Major changes to existing building spaces have been shown on Contract Drawings; minor changes have NOT been shown. Contractor shall anticipate that there will be numerous minor changes including:

1. Relocation of control piping and control wiring.
2. Relocation of thermostats, due to architectural revisions.
3. Relocation of diffusers and registers.

B. Electrical connections to existing equipment which is to be removed or relocated, including motors, shall be disconnected under DIVISION 26, ELECTRICAL WORK.

C. Electrical system equipment shall be relocated or removed under DIVISION 26, ELECTRICAL WORK.

D. Remove, store and relocate mechanical equipment designated to be relocated and reused.

E. Existing piping, ductwork, controls and mechanical system equipment which are located in areas designated for demolitions and which are not designated to remain shall be removed

under other DIVISIONS (by the General Contractor). Material which is removed and is not designated for reuse shall, at the Owner's option, either:

1. Be delivered to Owner's storage location, OR
2. Become Contractor's property and be removed from the site.

F. Existing piping, ductwork, controls or equipment which are to remain and which are disturbed or damaged during construction shall be replaced with appropriate new materials, equipment or components at no extra cost to the Owner.

END OF SECTION 230940