SECTION 230923

DIRECT DIGITAL CONTROL SYSTEMS

PART 1   GENERAL

1.1   SECTION INCLUDES

A.   Control equipment.

B.   Software.

1.2   RELATED SECTIONS

A.   Section 23 09 93 - Sequence of Operation.

B.   Section 26 05 05 - Equipment Wiring Systems.

1.3   REFERENCES

A.   ASHRAE 85 - Automatic Control Terminology for Heating, Ventilating, and Air Conditioning.

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

C.   NEMA EMC1 - Energy Management Systems Definitions.

1.4   DEFINITIONS

A.   Ensure terminology used in submittals conforms to ASHRAE 85, ASME MC85.1 and NEMA EMC1.

1.5   SYSTEM DESCRIPTION

A.   Automatic temperature control field monitoring and control system using field programmable microprocessor-based units with communications to Energy Management System specified herein.

B.   Central and remote hardware, software, and interconnecting wire and conduit.

C.   D.D.C. control modules for equipment as indicated on the drawings.

D.   Damper Motors and Valve Operators: Electronic.

1.6   SUBMITTALS

A.   Submit under the provisions of Division 01.

B.   Shop Drawings:
1.   Trunk cable schematic showing programmable control unit locations, and trunk data conductors.
2.   List of connected data points, including connected control unit and input device.
3.   System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
4.   System configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
5.   Descriptive data and sequence of operation of operating, user, and application software.

C.   Product Data: Provide data for each system component and software module.

D.   Manufacturer's Installation Instructions: Include for all manufactured components.

1.7   SUBMITTALS AT PROJECT CLOSEOUT

A.   Submit under the provisions of Division 01.

B.   Accurately record actual location of control components, including panels, thermostats, and sensors.

C.   Revise shop drawings to reflect actual installation and operating sequences.

D.   Include data specified in "Submittals" in final "Record Documents" form.

E.   Include interconnection wiring diagrams complete field installed system with identified and numbered, system components and devices.

F.   Include keyboard illustrations and step-by-step procedures indexed for each operator function.

G.   Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

1.8   QUALIFICATIONS

A.   Manufacturer: Company specializing in manufacturing the products specified in this Section with a minimum of five (5) years' documented experience.

B.   Installer: Company specializing in applying the work of this Section with a minimum of three (3) years' documented experience.

1.9   COORDINATION

A.   Ensure installation of components is complementary to installation of similar components in other systems.

B.   Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

C.   Ensure system is completed and commissioned.

1.10   MAINTENANCE SERVICE

A.   Furnish service and maintenance of energy management and control system for one year.

B.   Provide two complete inspections per year, one in each season, to inspect, calibrate, and adjust controls as required, and submit written reports.

1.11   PROTECTION OF SOFTWARE RIGHTS

A.   Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:
  1.   Limiting use of software to equipment provided under these specifications.
  2.   Limiting copying.
  3.   Preserving confidentiality.
  4.   Prohibiting transfer to a third party.

PART 2   PRODUCTS

2.1   MANUFACTURERS

A.   Trane (Native BACnet).

B.   Alerton (Native BACnet).

C.   Honeywell (Native BACnet).

D.   Delta (Native BACnet).

E.   Automated Logic (Native BACnet).

F.   Siemens (Native BACnet).

G.   Invensys Environmental.

H.   Johnson Controls (Native BACnet).

2.2   LOCAL OPERATOR ACCESS AND DISPLAY PANEL (TOUCH PAD)

A.   Provide local display and adjustment panel. Panels shall be portable or integral to programmable control unit. The panel contains a six-character digital display, and a numerical keyboard. Display and adjust:
1.   Input/output point information.
2.   Controller set points.
3.   Controller tuning constants.
4.   Program execution times.
5.   High and low limit values.
6.   Limit differential.
7.   Time, date, year.

B.   Provide two auxiliary keyboard pushbuttons for custom programming special functions. Provide dedicated pushbuttons for manual/auto override, system test, and enter functions.

C.   Provide status lights to announce the controller test, trouble, alarm, auto control, override, and auxiliary button operation.

2.3   OPERATOR STATION

A.   Central Processing Unit:
1.   Processor: 2 GHz.
2.   Random Access Memory: 2 GB.
3.   Hard Disk Drive: One (1) 40 GB capacity.
4.   CD Rom Drive: One (1) 48X speed internal.
5.   Ports: Two (2) USB 2.0, two (2) USB 3.1 Type C, and one (1) HDMI.

B.   Graphics Terminal Unit:
1.   Monitor: 17-inch diagonal size, color LED monitor with non-reflective screen, front access contrast and brightness control, line text display and minimum 1920 x 1080-pixel resolution.

C.   Keyboard:
      1.   The enhanced keyboard with 101-key layout shall contain a full ASCII complement and shall include a dedicated numeric keypad with separate ENTER key for rapid entry of date.

D.   Mouse:
      1.   The primary operator interface device shall consist of a two-button mouse.

2.4   CONTROL UNITS

A.   Units: Modular in design and consisting of processor board with programmable RAM memory, local operator access and display panel, and integral interface equipment.

B.   Battery Backup: For minimum of 100 hours for complete system including RAM without interruption, with automatic battery charger.

C.   Provide the following functions:
      1.   Mathematical: Absolute value, calculate, square root, power, sign, average, totalize.
      2.   Logic: OR/AND compare negate.
      3.   Fixed Formula: High and low select, span, rate, ramp, enthalpy, wet bulb, dew point, relative humidity, humidity ratio, filter.
      4.   Data Manipulation: Store, file and set.
      5.   Display Panel: Display adjust, override, time, day, date, year, alarm scan, override scan.
      6.   Control Routines: Proportional, integral, lead lag, hysteresis correction and incremental control.
      7.   Energy Management: Duty cycling, load shed, optimal run time, holiday, and daylight savings time correction.

D.   Provide self-test procedure for checking digital display and computer. Display advisories for maintenance, performance, or software problems. Identify variables as reliable or unreliable. Variables identified as unreliable will flash when displayed and calculation will use default.

E.   Indicate alarms and deviations. Alarm scan shows alarms and identification. Continue alarm indication until acknowledged and alarm condition is corrected.

F.   Provide two communication interface ports permitting communication between processor, process interface equipment, other processors, and central processing unit.

G.   Provide an asynchronous serial port for the interface of maintenance personnel's portable computer. All network interrogation shall be possible through this port.

2.5   DATA INTERFACE UNITS

A.   Provide equipment required to connect all sensors, transducers and interface relays required to monitor and control equipment in sequence of operation.

2.6   INPUT/OUTPUT SENSORS

A.   Temperature:
      1.   Resistance temperature detectors with resistance tolerance of plus or minus 0.1 percent at 21 degrees C, interchangeability less than plus or minus 0.2 percent C, time constant of 13 seconds maximum for fluids and 200 seconds maximum for air.
      2.   Measuring current maximum 5 MA with maximum self-heat of 0.017 degrees C/MW in fluids and 0.008 degrees C/MW in fluids and 0.008 degrees C/MW in air.
      3.   Provide 3 lead wires and shield for input bridge circuit.

4. Use insertion elements in ducts not affected by temperature stratification or smaller than one square meter. Use averaging elements where larger or prone to stratification sensor length 2.5 m or 5 m as required.
5. Insertion elements for liquids shall be with brass socket with minimum insertion length of 2-1/2 inches.
6. Supply room sensors with locking cover.
7. Provide outside air sensors with watertight inlet fitting, shielded from direct rays of sun.

B. Humidity Sensors:
1. Elements: Accurate within 5 percent full range with linear output.
2. Room Sensors: With locking cover, span of 10 to 60 percent relative humidity.
3. Duct and Outside Air Sensors: With element guard and mounting plate, range of 0 - 100 percent relative humidity.

C. Static Pressure Sensors:
1. Unidirectional with ranges not exceeding 150 percent of maximum expected input.
2. Temperature compensated with typical thermal error or 0.06 percent of full scale in temperature range of 40 to 100 degrees F.
3. Accuracy: One percent full scale with repeatability 0.3 percent.
4. Output: 0 - 5 vdc with power at 12 to 28 vdc.

D. Equipment Operation Sensors:
1. Status Inputs for Fans: Differential pressure switch with adjustable range of 0 to 5 inches wg.
2. Status Inputs for Pumps: Differential pressure switch piped across pump with adjustable pressure differential range of 8 to 60 psi.
3. Status Inputs Where Differential Pressure Sensing is Impractical: Current sensitive relay with current transformers, adjustable and set to 175 percent of rated motor current.

E. Digital to Pneumatic Transducers: Convert continuous proportional current or voltage to 0 to 20 psi.

F. Damper Position Indication: Potentiometer mounted in handbox enclosure with adjustable crankarm assembly connected to damper to transmit 0 - 100 percent damper travel.

G. Carbon Monoxide Detectors:
1. Single or multichannel dual level detectors, using solid state sensors with three-year minimum life. Sensor replacement shall take maximum 15 minutes. Suitable over temperature range of 23 to 130 degrees F.
2. Provide individual indicators and contactors for each level, initially calibrated for 50 ppm and 100 ppm.
3. The maximum response time to 100 ppm CO calibration gas shall be two minutes.

2.7   D.D.C. APPLICATIONS SYSTEM SOFTWARE

A. System Format:
1. Divide points of control or monitoring by system.
2. Identify points with unique, structured point identifier reflecting "specific area" or "specific system", and "specified point".

B. Input Process:
1. Select, from menu, one of four general types of commands based upon password clearance, command points, information points, build parameters, and modify parameters. Commands not available by password clearance shall be deleted from video display.
2. Enter memory changes through keyboard.

3. Select entry modes, Aid or Direct, based on operator's degree of capability and familiarity with system.
4. Aid Mode shall prompt operator through each step indicating available options.
5. Direct Mode shall allow experienced operator to input command string directly.
6. Enter commands as alpha/numeric character strings. Where commands require data for limits, setpoint, and time, enter value in same engineering units as controlled variable.
7. Operator input shall not inhibit alarm reporting. Echo input on associated output device, to either execute or abort.

C. Operator Access Control: Restrict any operator commands through use of software password.

D. Information Access: Obtain point status information from any designated output device with access command. Point status consists of point identification, numerical value (analog points) and associated engineering units, and individual function label indicating that point is on or off or in Alarm Normal condition. Output includes date and time of execution.

E. Point Display: Video display includes status of single point or group of points with high and low limits (if applicable). Refresh the display at least every 20 seconds.

F. Alarm summary includes status of points in Alarm condition.

G. Off-normal summary includes status of points in Off-Normal condition.

H. Alarm Reporting:
1. Alarm outputs contain descriptor, point identification, point data, engineering units, and date and time.
2. Print online changeable message, up to 60 characters in length, for each alarm point specified, immediately.
3. Display alarm reports on video. Display multiple alarms in order of occurrence.
4. Inhibit reporting of associated analog and binary alarms upon HVAC system shutdown. Upon restart, inhibit alarm reporting for operator pre-determined time.
5. Operator specifies if alarm required acknowledgment.

I. Advisories:
1. Lockout summary which contains status of points in locked out condition.
2. Continuously interrogate system hardware and programmable control units for failure or tampering and report if operational or not operational.
3. Power failure detection, time, and date.
4. System communication failure with operator device, field interface unit, point, programmable control unit.

J. Data Base Save/Restore:
1. Provide program which allows saving or restoring of operating data.
2. The disk unit shall save or restore system operating data.
3. Data includes:
    a) Analog limits and differentials.
    b) Start-stop times.
    c) Access/secure times.
    d) Lockout/unlock times.
    e) Setpoint values and adjustment times.
    f) Limits and differential values.
    g) Totalization points, limits, and current values
    h) Alarm messages and their assignments.
    i) Load control program operational parameters.
    j) HVAC control program operational parameters.

K.   Power Failure Motor Restart: Provide program to restore systems to normal operating conditions following power outage, and to enforce emergency operating conditions during power outage. Automatically restart loads to correct operating condition if normal or emergency power is available.

2.8   BASIC OPERATING FEATURES

A.   Binary Capabilities:
1.   Monitor binary sensors, continuously storing present contact condition in memory.
2.   Indicate if the point is off-normal, in alarm, or off- line.
3.   Program output points for Open/Closed, Test/Reset, Start/Stop.
4.   Feedback Start/Stop points. Employ point unique, feedback delay timer to temporarily suppress alarm reporting after input to allow time for response.
5.   Output advisory message if response is not as commanded.
6.   Hold points in present operating condition if controls power failure occurs.

B.   Analog Capabilities:
1.   Measure, transduce, transmit and display analog values.
2.   Express analog point values in proper engineering units, displaying with up to six significant digits.
3.   Have sensor to readout accuracy of plus or minus 0.5 degrees F.
4.   Use English system of measurement.
5.   Provide for operator designated ranges either linear, series of linear approximations, split ranges, or square root extractions of exponential functions.
6.   Compare analog read to high and low limits and announce the Alarm or Off-Normal condition.
7.   Output alarm, including point identification current value and associated engineering units, high or low value, and time and date.
8.   Automatically disable alarm reporting upon associated system shutdown. Allow sufficient time to return to normal operating conditions before allowing alarm reporting.
9.   Provide limit and differential summary.

C.   Analog Point Adjust:
1.   Remotely adjust controller set points or dampers. Automatically adjust points based upon preselected time or value.
2.   Employ feedback so that if a point fails to respond, responds with wrong value, or drifts from set point value by plus or minus 2 percent, output alarm message. Employ feedback delay timer to temporarily suppress alarm reporting after input to allow time for response.
3.   Hold points in present operating condition if controls power failure occurs.

D.   Automatic Alarm Lockout: Automatically inhibit alarm reporting of analog and binary points upon associated system shutdown. Inhibit reporting for operator predetermined time, upon restart of HVAC systems.

2.9   LOAD CONTROL PROGRAMS

A.   General:
1.   Provide means to reduce electrical energy usage, using control algorithms designed for electrical energy control.
2.   Apply algorithms to other energy sources, such as steam or natural gas.
3.   Support English units of measurement.

B. Demand Limiting:
1. Monitor total power consumption per power meter and shed associated loads automatically to reduce power consumption to an operator-preset able maximum demand level.
2. Use floating window type demand determination to monitor demand and compare to target value.
3. Automatically shed loads throughout the demand interval selecting loads with independently adjustable on and off time of between one and 255 minutes.
4. Output advisory if loads are not available to satisfy required shed amount, advise shed requirements and requiring operator acknowledgment.
5. Operator commands:
   a) Add/delete demand meter point.
   b) Define load point.
   c) Define load priority target.
   d) Define control target.
   e) Begin a new billing period.
   f) Lock/unlock program.
   g) Activate/inactivate/restore load.
   h) Request load control system control summary.
   i) Request load control system load summary.
6. Load control system summary:
   a) Demand interval.
   b) Current kW power and measured demand.
   c) Projected load limit.
   d) Total energy available from HVAC system.
   e) Maximum, average, and current expendable load.
   f) Maximum, average and current deferrable load.
   g) Demand limit status, target value, and recent control action.
   h) Duty cycle status, target value, and recent control action.
   i) Convergence time.
   j) Restore band width.
7. Load summary:
   a) Load priority.
   b) Expendable/deferrable load type.
   c) Point type, ID, status.
   d) Load rating.
   e) Minimum off, maximum off, and minimum on times.

C. Duty Cycling:
1. Periodically turn selected loads off to evenly reduce power consumption to target value, selecting loads with independently adjustable on and off time of between one and 255 minutes.
2. Operator commands:
   a) Define load point.
   b) Define control target.
   c) Activate/inactivate/restore load.
   d) Request load control system load summary.

2.10   HVAC CONTROL PROGRAMS

A. General:
1. Support English units of measurement.
2. Identify each HVAC Control system.

B. Optimal Run Time:
1. Control start-up and shutdown times of HVAC equipment for both heating and cooling.

2. Based on occupancy schedules, outside air temperature, seasonal requirements, and interior room mass temperature.
3. Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.
4. Use outside air temperature to determine early shut down with ventilation override.
5. Analyze multiple building mass sensors to determine seasonal mode and worse case condition for each day.
6. Operator commands:
   a) Define time schedule.
   b) Add/delete fan status point.
   c) Add/delete outside air temperature point.
   d) Add/delete mass temperature point.
   e) Define heating/cooling parameters.
   f) Define mass sensor heating/cooling parameters.
   g) Lock/unlock program.
   h) Request optimal run time control summary.
   i) Request optimal run time mass temperature summary.
   j) Request HVAC point summary.
   k) Request HVAC saving profile summary.
7. Control summary:
   a) HVAC Control system begin/end status.
   b) Optimal run time lock/unlock control status.
   c) Heating/cooling mode status.
   d) Optimal run time schedule.
   e) Start/stop times.
   f) Selected mass temperature point ID.
   g) Optimal run time system normal start times.
   h) Occupancy and vacancy times.
   i) Optimal run time system heating/cooling mode parameters.
8. Mass temperature summary:
   a) Mass temperature point type and ID.
   b) Desired and current mass temperature values.
   c) Calculated warm-up/cool-down time for each mass temperature.
   d) Heating/cooling season limits.
   e) Break point temperature for cooling mode analysis.
   f) Linear compensation factor for heating mode analysis.
9. HVAC point summary:
   a) Control system identifier and status.
   b) Fan status point ID and status.
   c) Outside air temperature point ID and status.
   d) Mass temperature point ID and status.
   e) Calculated optimal start and stop times.
   f) Period start.

C. Supply Air Reset:
1. Monitor heating and cooling loads in building spaces, terminal reheat systems, both hot deck and cold deck temperatures on dual duct and multizone systems, single zone unit discharge temperatures.
2. Adjust discharge temperatures to most energy efficient levels satisfying measured load by:
   a) Raising cooling temperatures to the highest possible value.
   b) Reducing heating temperatures to the lowest possible level.
3. Operator commands:
   a) Add/delete fan status point.
   b) Lock/unlock program.

c) Request HVAC point summary.
d) Add/Delete discharge controller point.
e) Define discharge controller parameters.
f) Add/delete air flow rate.
g) Define space load and load parameters.
h) Request space load summary.
4. Control summary:
a) HVAC control system status (begin/end).
b) Supply air reset system status.
c) Optimal run time system status.
d) Heating and cooling loop.
e) High/low limits.
f) Deadband.
g) Response timer.
h) Reset times.
5. Space load summary:
a) HVAC system status.
b) Optimal run time status.
c) Heating/cooling loop status.
d) Space load point ID.
e) Current space load point value.
f) Control heat/cool limited.
g) Gain factor.
h) Calculated reset values.
i) Fan status point ID and status.
j) Control discharge temperature point ID and status.
k) Space load point ID and status.
l) Air flow rate point ID and status.

D. Enthalpy Switchover:
1. Calculate outside and return air enthalpies using measured temperature and relative humidity; determine energy expended and control outside and return air dampers.
2. Operator commands:
a) Add/delete fan status point.
b) Add/delete outside air temperature point.
c) Add/delete discharge controller point.
d) Define discharge controller parameters.
e) Add/delete return air temperature point.
f) Add/delete outside air dewpoint/humidity point.
g) Add/delete return air dewpoint/humidity point.
h) Add/delete damper switch.
i) Add/delete minimum outside air.
j) Add/delete atmospheric pressure.
k) Add/delete heating override switch.
l) Add/delete evaporative cooling switch.
m) Add/delete air flow rate.
n) Define enthalpy deadband.
o) Lock/unlock program.
p) Request control summary.
q) Request HVAC point summary.
3. Control summary:
a) HVAC control system begin/end status.
b) Enthalpy switchover optimal system status.
c) Optimal return time system status.
d) Current outside air enthalpy.
e) Calculated mixed air enthalpy.

f) Calculated cooling cool enthalpy using outside air.
g) Calculated cooling cool enthalpy using mixed air.
h) Calculated enthalpy difference.
i) Enthalpy switch over deadband.
j) Status of damper mode switch.

2.11 CHILLER CONTROL PROGRAMS

A. Control function of condenser water reset, chilled water reset, and chiller sequencing. Support English units of measurement.

B. Condenser Water Reset: Automatically reset controlled condenser water temperature using measured outside wet bulb temperature and load being handled.

C. Chilled Water Reset: Automatically reset controlled chilled water temperature satisfying cooling coil requiring greatest cooling.

D. Chiller Sequencing: Determine which combination of chillers will most efficiently satisfy chilled water load, by cycling chillers, based on comparing load to switchover limits defined for each chiller.

2.12 PROGRAMMING APPLICATION FEATURES

A. Trend Point:
1. Sample up to 10 points, real or computed, with each point capable of collecting 100 samples at intervals specified in minutes, hours, days, or month.
2. Output trend logs as line graphs or bar graphs. Output graphic on terminal, with each point for line and bar graphs designated with a unique color, vertical scale either actual values or percent of range, and horizontal scale time base. Print trend logs up to 12 columns of one point/column.

B. Alarm Messages:
1. Allow definition of minimum of 10 messages, each having minimum length of 60 characters for each individual message.
2. Assign alarm messages to system messages including point's alarm condition, point's off-normal condition, totalized point's warning limit, and hardware elements advisories.
3. Output assigned alarm with "message requiring acknowledgment".
4. Operator commands include define, modify, or delete; output summary listing current alarms and assignments; output summary defining assigned points.

C. Weekly Scheduling:
1. Automatically initiate equipment or system commands, based on preselected time schedule for points specified.
2. Provide program times for each day of week, per point, with one minute resolution.
3. Automatically generate alarm output for points not responding to command.
4. Provide for holidays, minimum of 366 consecutive holidays.
5. Operator commands:
a) System logs and summaries.
b) Start of stop point.
c) Lock or unlock control or alarm input.
d) Add, delete, or modify analog limits and differentials.
e) Adjust point operating position.
f) Change point operational mode.
g) Open or close point.
h) Enable/disable, lock/unlock, or execute interlock sequence or computation profile.
i) Begin or end point totalization.

           j)   Modify totalization values and limits.
           k)   Access or secure point.
           l)   Begin or end HVAC or load control system.
           m)   Modify load parameter.
           n)   Modify demand limiting and duty cycle targets.

      6.   Output summary: Listing of programmed function points, associated program times, and respective day of week programmed points by software groups or time of day.

D.   Interlocking:
      1.   Permit events to occur, based on changing condition of one or more associated master points.
      2.   Binary contact, high/low limit of analog point or computed point shall be capable of being utilized as master. The same master may monitor or command multiple slaves.
      3.   Operator commands:
           a)   Define single master/multiple master interlock process.
           b)   Define logic interlock process.
           c)   Lock/unlock program.
           d)   Enable/disable interlock process.
           e)   Execute terminate interlock process.
           f)   Request interlock type summary.

PART 3   EXECUTION

3.1   INSTALLATION

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

B.   Install electrical work in accordance with Section 26 05 05. Electrical material and installation shall be in accordance with the appropriate requirements of Division 26.

C.   Provide 120v AC, 15-amp dedicated emergency power circuit to each programmable control unit.

3.2   MANUFACTURER'S FIELD SERVICES

A.   Include installing and debugging hardware and software. Perform hardware configuration revisions required to accommodate software patches.

B.   Enter building management database and provide backup copy on removable flexible disk.

C.   Prepare and start systems under the provisions of Division 01.

D.   Provide basic operator training for 5 persons on data display, alarm, and status descriptors, requesting data, execution of commands and request of logs. Include a minimum of 40 hours dedicated instructor time.

3.3   DEMONSTRATION

A.   Provide systems demonstration under the provisions of Division 01.

B.   Demonstrate complete and operating system to Owner.

3.4   FIELD QUALITY CONTROL

A.   Field inspection and testing will be performed under the provisions of Division 01.

B.   Test each sequence of building management system by simulation of normal, off normal and alarm conditions.

3.5   ADJUSTING

A.   Adjust work under the provision of Division 01.

B.   Adjust setpoints, alarm points, and display configurations so that system performs as specified.

3.6   CLEANING

A.   Clean work under the provisions of Division 01.

B.   Clean equipment finishes and interiors of equipment cabinets.

END OF SECTION