SECTION 23 0923
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 GENERAL

1.01 RELATED WORK UNDER OTHER SECTIONS:
   A. In addition to the general building construction, work directly related to the automatic
temperature control systems which will be provided by others or described under other sections
of these specifications includes the following:
   B. Controls valves, differential water pressure sensors, and water temperature sensors shall be
furnished under this section of the specifications, but installed under the HEAT TRANSFER
section of these specifications.
   C. Section 23 0913 - Instrumentation and Control Devices for HVAC.
   D. Section 23 0993 - Sequence of Operations for HVAC Controls.
   E. Section 26 2717 - Equipment Wiring: Electrical characteristics and wiring connections.

1.02 REFERENCE STANDARDS
   A. NFPA 70 - National Electrical Code; National Fire Protection Association; Most Recent Edition
   Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and
   Supplements.

1.03 GENERAL REQUIREMENTS
   A. The Honeywell EBI front-end located at UND Facilities Management shall be referred to as the
   UND BAS Front-end (Building Automation System) from here on. It is the sole front-end that all
   building controllers must integrate to.
   B. The work covered under this section of the specifications shall consist of furnishing all labor,
   equipment, supplies and all materials and performing all operations necessary for the automatic
temperature control work as hereinafter described and/or shown on the accompanying
drawings.
   C. Automatic Temperature Control systems shall be complete with all controllers, programming,
sensors, thermostats, actuators, control valves, relays, switches, electrical wiring, compressed
   air tubing, and accessory items as required for a complete and operating system.
   D. There may be pneumatic work that will include disconnection and in some cases reconnection
   of pneumatics heating and ventilation equipment. All lines need to be capped at the end of the
day by the contractor. For all equipment affected by the project, the pneumatics should be
   upgraded to electronic controls unless authorized in writing by UND Facilities Management.
   E. The work shall be in accordance with this and other applicable specification sections and with
   the applicable drawings.
   F. Direct network access from the UND BAS Front-end at UND Facilities Management shall be
   required for control of commands, setpoints, schedules, and monitoring of all points and alarms.
   Owner approved point names, descriptors, and point attributes of each point in the field shall be
   provided as per the owners’ requirements. This shall be coordinated with the UND Facilities
   Management and returned possibly with corrections to the Automatic Temperature Controls
   Contractor within two weeks of receipt. All software and programming in the field required for
   this function shall be included.
   G. There shall be two Ethernet jacks for each controller cabinet that has a supervisory controller
   which communicates via Ethernet. One jack shall be connected with a patch cord to the
   supervisory controller. The second is to access the network with a laptop or workstation. Refer
to the drawings for the location of the two jacks. If the location is not indicated on the drawings,
the controls contractor shall coordinate the location with the engineer and UND Facilities
Management. It is important to UND Facilities Management that we keep the number of
supervisory controllers to a minimum to ensure a more robust network that relies less on
Ethernet and more upon bus communication wiring between controllers. An example would be
sharing an outside air sensor across the communication bus instead of relying on Ethernet communication between controllers. The engineer shall identify the locations for all Ethernet jacks on the project.

H. The Automatic Temperature Controls Contractor shall coordinate with UND Facilities Management to resolve any communication, point commanding, or alarming problems that arise from the connection of the building controllers to the Honeywell EBI front-end. It is also the controls contractor responsibility to provide a complete points list once UND Facilities Management has approved the point names.

I. The controls contractor shall perform the necessary tests to ensure that the system performs as required and in an integrated manner.

1.04 SUBMITTALS

A. Shop Drawings: Shop drawings shall be submitted in accordance with the general requirements of these specifications and reviewed by UND Facilities Management before project work begins. Allow a minimum of two weeks for review. Shop drawings shall include the following:

B. Information for the controls equipment shall include the bill of materials of equipment indicating quantity, manufacturer, and model number

C. Heat pump, variable air volume (VAV) boxes, radiation, cabinet unit heater, exhaust fan, and variable frequency drive (VFD) schedules
   1. Schedules shall include area served, sensor location, the air handler the VAV or heat pump is served by, min and max CFM setpoints, inlet size, valve information, and any other information pertinent to the installation.

D. Equipment schedules shall include area served, sensor location, serial numbers, and valve information.

E. Valve Schedule shall include the unit number manufacturer and model number, unit served, type, action (direct or reverse), normal position, flow GPM, op, Temperature F, etc.

F. Damper Schedule

G. Air Flow Measuring Stations

H. Building Pressure Sensors

I. Thermostat/Sensor Schedule shall include the sensor location, area served, unit served, manufacturer and model.

J. Data sheets for all Control Components

K. CAD Generated Control System Schematic and Wiring Diagrams in electronic form with software compatible with AutoCAD, Microsoft Visio, or other owner approved software.

L. Control Panel Locations noted on a Building One-line

M. Bus communication topology that includes building controllers and application specific controllers shall be shown on a building one-line. This should include a riser that shows the order of controllers and a building one-line showing the route of the bus communication throughout the building.

N. Power wiring topology shall be shown on a building one-line that shows panel name, breaker, and transformer location. This should include a building one-line showing the route of the power wiring for controllers throughout the building. This should be provided by the engineer in AutoCAD.

O. Sequences of Operation that reflect how the equipment was programmed with any safeties included that may protect the mechanical equipment or building.

P. Complete list of point names and their associated controllers.

Q. Operation and Maintenance Manuals: Operation and maintenance manuals shall be provided as required in the MECHANICAL GENERAL REQUIREMENTS SECTION of these specifications. Manufacturer’s hardware and software owner’s manual and user’s manuals as
well as the “as-built” corrections to all shop drawing submittals shall be included. A paper and electronic copy shall be provided.

R.
1. See Section 01 3000 - Administrative Requirements, for submittal procedures.
2. Product Data: Provide data for each system component and software module.

1.05 QUALITY ASSURANCE
A. Installer Qualifications: All bidders must be in the business of installing and servicing similar BMS systems using direct digital controls for over ten (10) years.
B. All bidders must be original equipment manufacturers and shall have been regularly engaged in engineering, programming, installation and service of such systems or licenses representatives and installers of the approved original equipment manufacturers specified here in.
C. All bidders shall have a local engineering and service offices within 100 miles and should be able to support the project with the required manpower and equipment resource.
D. Owner Instruction Qualifications: Engage personnel familiar with installed control system and qualified for teaching of maintenance personnel.
E. The direct digital control (DDC) system shall be listed by the Underwriters Laboratories, Inc. for Enclosed Energy Management Equipment under UL #916.
F. Direct digital control panels shall comply with Federal Communications Commission (FCC) Regulation, Part 15, Subpart J, for Class A computing devices.
G. All wiring shall be in accordance with the National Electrical Code and all local electrical codes. In addition, IEEE standards shall be followed.
H. Perform work in accordance with NFPA 70.

1.06 WARRANTY
A. All automatic temperature control system devices and installation shall be guaranteed to be free from defects in workmanship and material for a period of two (2) years from the date of Project Substantial Completion. Any equipment, software, or labor found to be defective during this period shall be replaced without expense to the owner.
B. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

PART 2 PRODUCTS
2.01 MANUFACTURERS
   1. ComfortPoint IPC/Open BACnet Controls
B. Johnson Controls, Inc; Johnson Controls Branch, Fargo, ND: www.johnsoncontrols.com.
   1. Johnson Metasys BACnet Controls

2.02 SYSTEM DESCRIPTION
A. Automatic temperature control field monitoring and control system using field programmable micro-processor based units with communications to Building Management System.
B. Base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.
C. Include computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.
D. Controls for variable air volume terminals, radiation, reheat coils, unit heaters, fan coils, and the like when directly connected to the control units. Individual terminal unit control is specified in Section 23 0913.
E. Provide control systems consisting of thermostats, control valves, dampers and operators, indicating devices, interface equipment and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.
F. Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

2.03 CONTROLLERS
A. BUILDING CONTROLLERS
   1. General:
      a. Manage global strategies by one or more, independent, standalone, microprocessor based controllers.
      b. Provide sufficient memory to support controller's operating system, database, and programming requirements.
      c. Share data between networked controllers.
      d. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
      e. Utilize real-time clock for scheduling.
      f. Continuously check processor status and memory circuits for abnormal operation.
      g. Controller to assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
      h. Communication with other network devices to be based on assigned protocol.
   2. Communication:
      a. Controller to reside on a BACnet network using ISO 8802-3 (ETHERNET) Data Link/Physical layer protocol.
      b. Perform routing when connected to a network of custom application and application specific controllers.
      c. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.
   3. Anticipated Environmental Ambient Conditions:
      a. Outdoors and/or in Wet Ambient Conditions:
         1) Mount within waterproof enclosures.
         2) Rated for operation at 40 to 150 degrees F.
      b. Conditioned Space:
         1) Mount within dustproof enclosures.
         2) Rated for operation at 32 to 120 degrees F.
   4. Provisions for Serviceability:
      a. Diagnostic LEDs for power, communication, and processor.
      b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.
   5. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
   6. Power and Noise Immunity:
      a. Maintain operation at 90 to 110 percent of nominal voltage rating.
      b. Perform orderly shutdown below 80 percent of nominal voltage.
      c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.
B. CUSTOM APPLICATION CONTROLLERS
   1. Supervisory controllers shall be used to manage and schedule global control strategies on the network and communicate back to the Honeywell EBI front-end. There should be one supervisory controller per building. If a controls contractor would like to add more than one supervisory controller in a building it must be approved by UND Facilities Management Building Automation.
   2. Each supervisory controller shall include its own microprocessor, program and data memory, power supply, network communications module, and battery. All program and data memory shall be read/write random access memory (RAM) type. The battery shall be capable of supporting all memory within the controller for a minimum of 72 hours if commercial power to the unit is interrupted. Upon the resumption of normal power, the
runtime control software shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.

3. Supervisory controllers may also include input/output terminals. The supervisory controller may have one mechanical piece of equipment wired and programmed to it. Additional miscellaneous points may also be wired to the supervisory controller.

4. Modular type controllers where there is a central processing unit (CPU) controlling many pieces of mechanical equipment with many input or output modules attached will not be allowed.

5. The supervisory controller shall be capable of sharing its point and data information with other controllers on the network. The network of controllers shall include all controllers within the building.

6. The controllers shall communicate over BACnet/IP at the supervisory controller and MS/TP between application specific controllers.

7. To keep the integrity of the controls network, there shall be one network jack per building for the supervisory controller. This will keep all communication between controllers on the BACnet MS/TP network. We do not want to rely on Ethernet to share data between the controllers. The network jacks shall be located inside the controls panel. The network jack shall be included in the controls contractor bid. If additional jacks are needed, they need to be approved by UND Facilities Management Building Automation.

8. Each controller shall be programmed with UND standard point names and descriptors for the particular building, piece of equipment, and application.

9. General:
   a. Provide sufficient memory to support controller's operating system, database, and programming requirements.
   b. Share data between networked, microprocessor based controllers.
   c. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
   d. Utilize real-time clock for scheduling.
   e. Continuously check processor status and memory circuits for abnormal operation.
   f. Controller to assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
   g. Communication with other network devices to be based on assigned protocol.

10. Communication:
    a. Controller to reside on a BACnet network using MS/TP Data Link/Physical layer protocol.
    b. Provide service communication port for connection to a portable operator’s terminal or hand held device with compatible protocol.

11. Anticipated Environmental Ambient Conditions:
    a. Outdoors and/or in Wet Ambient Conditions:
       1) Mount within waterproof enclosures.
       2) Rated for operation at -30 to 150 degrees F.
    b. Conditioned Space:
       1) Mount within dustproof enclosures.
       2) Rated for operation at 32 to 120 degrees F.

12. Provisions for Serviceability:
    a. Diagnostic LEDs for power, communication, and processor.
    b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.

13. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.

14. Power and Noise Immunity:
    a. Maintain operation at 90 to 110 percent of nominal voltage rating.
    b. Perform orderly shutdown below 80 percent of nominal voltage.
c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.

C. APPLICATION SPECIFIC CONTROLLERS
1. Application specific controllers shall be used to control HVAC equipment such as air handlers, heat exchangers, VAV’s, heat pumps, cabinet unit heaters, etc.
2. Each application specific controller shall include its own microprocessor, program and data memory, power supply, and input/output modules. All program and data memory shall be read/write random access memory (RAM) type. Upon the resumption of normal power, the runtime control software shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.
3. The application specific controller may have one mechanical piece of equipment wired and programmed to it. Additional miscellaneous points may also be wired to the application specific controller.
4. Modular type controllers where there is a central processing unit (CPU) controlling many pieces of mechanical equipment with many input or output modules attached will not be allowed.
5. Each application specific controller shall be capable of sharing point and data information with other controllers, such that control sequences or control loops executing in one controller may receive input signals from sensors connected to other controllers on the network. The network includes the controllers within the building. If the network communication link fails or the originating controller malfunctions, the control loop shall continue to function using the last value received from the failed controller. Failure of one controller shall have no other effect upon any of the other controllers in the network.
6. All controllers must have PID loops controls that can be field adjusted to increase or decrease the speed of response and improve system stability. PID loop controls will be adjusted during the startup and commissioning phase of the project. Control tolerances, stability and response times are defined in the commissioning section.
7. Each controller shall be programmed with UND standard point names and descriptors for the particular building, piece of equipment, and application.
10. Communication:
   a. Controller to reside on a BACnet network using MS/TP Data Link/Physical layer protocol.
   b. Provide service communication port for connection to a portable operator’s terminal or hand held device with compatible protocol.
11. Anticipated Environmental Ambient Conditions:
   a. Outdoors and/or in Wet Ambient Conditions:
      1) Mount within waterproof enclosures.
      2) Rated for operation at -30 to 150 degrees F.
   b. Conditioned Space:
      1) Mount within dustproof enclosures.
      2) Rated for operation at 32 to 120 degrees F.
12. Provisions for Serviceability:
   a. Diagnostic LEDs for power, communication, and processor.
   b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.
13. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
14. Power and Noise Immunity:
   a. Maintain operation at 90 to 110 percent of nominal voltage rating.
   b. Perform orderly shutdown below 80 percent of nominal voltage.
   c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.
D. INPUT/OUTPUT INTERFACE

1. Hardwired inputs and outputs tie into the DDC system through building, custom application, or application specific controllers.

2. All Input/Output Points:
   a. Protect controller from damage resulting from any point short-circuiting or grounding and from voltage up to 24 volts of any duration.
   b. Provide universal type for building and custom application controllers where input or output is software designated as either binary or analog type with appropriate properties.

3. Binary Inputs:
   a. Allow monitoring of On/Off signals from remote devices.
   b. Provide wetting current of 12 mA minimum, compatible with commonly available control devices and protected against the effects of contact bounce and noise.
   c. Sense dry contact closure with power provided only by the controller.

4. Pulse Accumulation Input Objects: Conform to all requirements of binary input objects and accept up to 10 pulses per second.

5. Analog Inputs:
   a. Allow for monitoring of low voltage 0 to 10 VDC, 4 to 20 mA current, or resistance signals (thermistor, RTD).
   b. Compatible with and field configurable to commonly available sensing devices.

6. Binary Outputs:
   a. Used for On/Off operation or a pulsed low-voltage signal for pulse width modulation control.
   b. Outputs provided with three position (On/Off/Auto) override switches.
   c. Status lights for building and custom application controllers to be selectable for normally open or normally closed operation.

7. Analog Outputs:
   a. Monitoring signal provides a 0 to 10 VDC or a 4 to 20 mA output signal for end device control.
   b. Provide status lights and two position (AUTO/MANUAL) switch for building and custom application controllers with manually adjustable potentiometer for manual override on building and custom application controllers.
   c. Drift to not exceed 0.4 percent of range per year.

8. Tri State Outputs:
   a. Coordinate two binary outputs to control three point, floating type, electronic actuators without feedback.
   b. Limit the use of three point, floating devices to the following zone and terminal unit control applications:
      1) VAV terminal units.
      2) Radiation.
   c. Control algorithms run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

9. System Object Capacity:
   a. Hardware additions or software revisions for the installed operator interfaces are not to be required for future, system expansions.

2.04 POWER SUPPLIES AND LINE FILTERING

A. All low voltage and line voltage wiring required for the installation of the Automatic Temperature Controls is by this contractor. A separate dedicated power circuit shall be run to each of the following: supervisory controller panels, actuators, and application specific controllers. There shall be a maximum number of 5 application specific controllers per transformer. All other equipment requiring line voltage power shall be allowed to be supplied off of another power circuit within the building. Coordinate all required electrical work, breakers within electrical panels, and sizing information with the electrical contractor on site prior to commencement of work.
B. Power Supplies:
   1. Provide UL listed control transformers with Class 2 current limiting type or over-current protection in both primary and secondary circuits for Class 2 service as required by the NEC.
   2. Limit connected loads to 80 percent of rated capacity.
   3. Match DC power supply to current output and voltage requirements.
   4. Unit to be full wave rectifier type with output ripple of 5.0 mV maximum peak to peak.
   5. Regulation to be 1 percent combined line and load with 100 microsecond response time for 50 percent load changes.
   6. Provide over-voltage and over-current protection to withstand a 150 percent current overload for 3 seconds minimum without trip-out or failure.
   7. Operational Ambient Conditions: 32 to 120 degrees F.
   8. EM/RF meets FCC Class B and VDE 0871 for Class B and MIL-STD 810 for shock and vibration.
   9. Line voltage units UL recognized and CSA approved.

C. Power Line Filtering:
   1. Provide external or internal transient voltage and surge suppression component for all workstations and controllers.
   2. Minimum surge protection attributes:
      a. Dielectric strength of 1000 volts minimum.
      b. Response time of 10 nanoseconds or less.
      c. Transverse mode noise attenuation of 65 dB or greater.
      d. Common mode noise attenuation of 150 dB or greater at 40 to 100 Hz.

2.05 LOCAL AREA NETWORK (LAN)
   A. Provide communication between control units over local area network (LAN).
   B. Break in Communication Path: Alarm and automatically initiate LAN reconfiguration.
   C. Network Support: Time for global point to be received by any station, shall be less than 3 seconds. Provide automatic reconfiguration if any station is added or lost. If transmission cable is cut, reconfigure two sections with no disruption to system’s operation, without operator intervention.

2.06 CONTROLLER SOFTWARE
   A. The BACnet controllers must be programmed using one of the following graphical object oriented programming tools for maintenance and usability.
      1. Honeywell ComfortPoint Open Tool
      2. Metasys System Configuration Tool (SCT)
   B. The above programming tools used by the Automatic Temperature Controls Contractor must be the same programming tool that is made available to UND Facilities Management as a customer.
   C. All BACnet point alarming shall be configured through the BACnet notification class object. UND Facilities Management shall provide the correct BACnet notification classes to which alarmable points shall be assigned. The alarm limit values shall be writable from the Honeywell EBI front-end. The UND standard points list shall be used to show which points should have alarming enabled and at what value the point will alarm.
   D. Alarm messaging for BACnet points must be configured at the controller for points with alarming enabled. The alarm description that is sent to the Honeywell EBI front-end will be provided in UND’s standard point list. The Automatic Temperature Controls Contractor shall work with the UND Facilities Management to ensure alarming reports correctly to the Honeywell EBI front-end at UND Facilities.
   E. All supervisory controllers and application specific controllers shall have schedules represented by BACnet Schedule objects. Schedules shall be able to be modified from the Honeywell EBI front-end. The controls contractor will need to work with the UND Facilities to setup appropriate
schedules for the mechanical equipment that serves offices, classrooms, labs, and other zones. The Automatic Temperature Controls Contractor shall work with the UND Facilities Management to ensure scheduling can be modified from the Honeywell EBI front-end at UND Facilities.

F. Identification from all hardware and software points shall be consistent for all controllers and follow UND’s standard descriptor labeling. Consistent names shall be used at all DDC panels to eliminate cross-reference or lookup tables.

G. Each controller shall be programmed with UND standard points list which properly identifies point names, descriptors, alarming, and alarm limits for a building, particular piece of equipment, and application.

H. All applications reside and operate in the system controllers and editing of all applications occurs at the operator workstation.

I. System Security:
   1. User access secured via user passwords and user names.
   2. Passwords restrict user to the objects, applications, and system functions as assigned by the system manager.
   3. User Log On/Log Off attempts are recorded.
   4. Automatic Log Off occurs following the last keystroke after a user defined delay time.

J. Object or Object Group Scheduling:
   1. Weekly Schedules Based on Separate, Daily Schedules:
      a. Include start, stop, optimal stop, and night economizer.
      b. 10 events maximum per schedule.
      c. Start/stop times adjustable for each group object.
   2. Exception Schedules:
      a. Based on any day of the year.
      b. Defined up to one year in advance.
      c. Automatically discarded and replaced with standard schedule for that day of the week upon execution.
   3. Holiday or Special Schedules:
      a. Capability to define up to 99 schedules.
      b. Repeated annually.
      c. Length of each period is operator defined.

K. Provide standard application for equipment coordination and grouping based on function and location to be used for scheduling and other applications.

L. Alarms:
   1. Binary object is set to alarm based on the operator specified state.
   2. Analog object to have high/low alarm limits.
   3. All alarming is capable of being automatically and manually disabled.

M. Maintenance Management: System monitors equipment status and generates maintenance messages based upon user-designated run-time limits.

N. Sequencing: Application software based upon specified sequences of operation in Section 23 0993.

O. PID Control Characteristics:
   1. Direct or reverse action.
   2. Anti-windup.
   3. Calculated, time-varying, analog value, positions an output or stages a series of outputs.

P. Staggered Start Application:
   1. Prevents all controlled equipment from simultaneously restarting after power outage.
   2. Order of equipment startup is user selectable.

Q. Anti-Short Cycling:
1. All binary output objects protected from short-cycling.
2. Allows minimum on-time and off-time to be selected.

R. On-Off Control with Differential:
1. Algorithm allows binary output to be cycled based on a controlled variable and set-point.
2. Algorithm to be direct-acting or reverse-acting incorporating an adjustable differential.

S. Run-Time Totalization:
1. Totalize run-times for all binary input objects.
2. Provides operator with capability to assign high run-time alarm.

2.07 HVAC CONTROL PROGRAMS
A. All necessary runtime control software to form a complete operating system as described in this specification shall be provided. The software programs specified in this section shall be provided as an integral part of the direct digital controllers and shall not be dependent upon any higher level computer for execution.

B. The runtime control software in the application specific controllers and terminal unit controllers shall have the ability to perform the following per-tested control algorithms and control functions:
1. Two Position Control Loops
2. Proportional Control Loops
3. Proportional plus Integral (PI) Control Loops
4. Proportional, Integral, plus Derivative (PID) Control Loops
5. Outdoor Air Reset Control
6. Minimum On/Off Times
7. Random Start Delay
8. Night Setback/Setup Control
9. Simultaneous Heating/Cooling Lockout
10. Point History Collection
11. Alarm Reporting
12. Change of Value Reporting

C. Point History Collection shall provide a record of value of analog I/O points over the last 72 hours, at 30-minute intervals, and a record of the last 50 status changes for binary type points with the capability of archiving data after that.

D. Runtime control software in the building controllers shall have the ability to perform any or all of the following system and energy management routines:
1. Time of Day Scheduling
2. Calendar Based Scheduling
3. Holiday Scheduling
4. Trending
5. Optimum Start
6. Optimum Stop
7. Peak Demand Limiting
8. Chiller Plant Optimization

E. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the Sequence of Operation.

F. Custom Process Programming Capability: Runtime control software shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

2.08 SYSTEM OPERATOR'S WORKSTATION:
A. Any controller installed must be compatible with the UND BAS Front-end. The controllers will communicate directly with the Honeywell EBI front-end at UND Facilities over the campus IP
network. The UND BAS Front-end is managed by Facilities Management and no other system servers or workstations will be allowed without written approval from Facilities Management.

2.09 SYSTEM FRONT END GRAPHICS:
   A. Shall be completed by UND Facilities Management noted in section 1.3 Front-end Graphic Work by Owner/UND Facilities Management.

PART 3 EXECUTION

3.01 EXAMINATION
   A. Verify existing conditions before starting work.
   B. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices, wiring, and pneumatic tubing is installed prior to installation proceeding.

3.02 INSTALLATION
   A. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
   B. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation. Refer to Section 23 0993.
   C. Provide conduit and electrical wiring in accordance with Section 26 2717. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

3.03 MANUFACTURER'S FIELD SERVICES
   A. Start and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.
   B. Provide service engineer to instruct Owner's representative in operation of systems plant and equipment for 3 day period.
   C. Provide basic operator training for ____ 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. Provide training on site.

3.04 DEMONSTRATION AND INSTRUCTIONS
   A. Demonstrate complete and operating system to Owner.

3.05 COMMISSIONING
   A. Manufacturer’s Field Services: Provide the services of a factory-authorized service representative to start control systems.
   B. Per the contractor’s request, UND Facilities will provide a temporary laptop computer adjacent to the building supervisory controller. Allow UND Facilities Management three working days to provide this workstation. Provide an operator's workstation on the laptop computer. When commissioning and training are completed, UND Facilities will remove the laptop computer.
   C. Test and adjust controls and safeties.
   D. Replace damaged or malfunctioning controls and equipment.
   E. Start, test, and adjust control systems.
   F. Demonstrate compliance with requirements.
   G. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.
   H. Tune the PID loop of all controllers so that the various devices maintain proper control when subjected to an incremental set point change.

3.06 OWNER INSTRUCTION
   A. Manufacturer’s Field Services: Provide the services of a factory-authorized service representative to demonstrate and train Owner's maintenance personnel as specified below.
B. The Automatic Temperature Controls Contractors technician who performed the project install shall be available for owner instruction and training.

C. Train Owner’s maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

D. Provide owner training on final as-built control drawings, all building controllers, software, and programming. Include a minimum of (##) hours of dedicated instructor time on-site. The owner must receive a minimum of 2 weeks to review the final as-built control drawings before training can be scheduled. The training sessions shall be split into different sessions to allow for follow-up on the previous training session. Training shall include classroom and onsite training. Engineering Note: Verify with UND Facilities Management on the number of hours required for training on this project.

END OF SECTION