SECTION 15900
TEMPERATURE CONTROL
AND
BUILDING AUTOMATION SYSTEM

PART 1 GENERAL

1.01 SCOPE OF WORK

Section includes:
Building Automation System (BAS) contractor shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with other open communications capabilities as herein specified.

1.03 WORK BY OTHERS

A. General:
Mechanical Contractor installs all control valves, taps, dampers, etc. furnished by BAS manufacturer.

A. Electrical Contractor provides all wiring shown on electrical drawings and
(designer note: this paragraph should be referenced also in section 16000):

1. Provide 120V power to all BAS control panels.

2. Wiring of all high and low voltage power feeds through all disconnect starters to electrical motor, or variable speed controllers.

3. Wiring of any remote start/stop switches, manual or automatic motor speed control devices.

4. Line or low voltage wiring other than control wiring of any electrical sub-metering devices furnished by BAS manufacturer.

1.04 RELATED WORK

A. Division 1:
General and Special Conditions.

B. Division 15:
Mechanical.

C. Division 16:
Electrical.

1.05 QUALITY ASSURANCE

A. General:
BAS system shall be designed and installed, commissioned and serviced by factory-trained personnel of local branch office of Novar / TREND Controls Corporation or TREND Certified “TREND Technology Center”. The “TREND Technology Center” shall have and in-place for a minimum of one year a certified “System Provider” with a support facility within 100 miles of the site. It shall have a technical staff, spare parts inventory and necessary test and diagnostic equipment.

E. UL Requirements:
All BAS peer-to-peer network controllers, central system controllers, floor level controllers, and local user displays shall be UL Listed under Standard UL 916 for Energy Management Equipment, and be so listed at time of Bid.

F. Compatibility Requirements:
This system shall have a documented history of compatibility to upgrade existing field panels to current level of technology, and extend new field panels on a previously installed network.

1.06 SUBMITTALS

A. General:
Submit following:

1. Auto-CAD compatible drawings.

2. Equipment data cut sheets.

3. System schematics, including:
   a. Sequence of operations.
   b. Point names.
   c. Point addresses.
   d. Interface wiring diagrams.
   e. Panel layouts.
   f. System riser diagrams.

B. Project Completion:
Upon project completion, submit operation and maintenance manuals, consisting of following:

1. Index sheet, listing contents in alphabetical order.

2. Manufacturer's equipment parts list of all functional components of system, Auto-CAD disk of system schematics, including wiring diagrams.

3. Description of sequence of operations.

5. Operator's Manual

1.07 WARRANTY

A. General:
Provide all services, materials and equipment necessary for successful operation of entire BAS system for a period of one year from date of final acceptance.

C. Support Services:
On-line support services shall allow local BAS subcontractor to dial out over telephone lines and or access via Intranet or Internet to monitor and control facility's building automation system. Building owner shall provide all private and public telephone lines, ISDN lines and Internet Service Provider services and connections at Owner’s direct cost. Remote connection to facility shall be within 1.5 hours of time that problem

is reported. This coverage shall be extended to include normal business hours, after business hours, weekends and holidays. If problem cannot be resolved with on-line or network support services, BAS manufacturer shall dispatch appropriate personnel to job site to resolve problem within 4 hours of time that problem is reported.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Building Automation System (BAS) Manufacturers:
System components shall be as manufactured by only the following: Novar / TREND. Novar / TREND Technology Center Authorized, System Providers shall be prior approved and directly employ certified installation, supervision and checkout technicians. System providers shall have fully staffed field office to be located within 100 miles of the jobsite for a minimum of 1 year prior to bid.

B. System Requirements:
A single manufacturer shall to greatest extent possible, manufacture system components.

2.02 SUPERVISORY SOFTWARE SYSTEM DESCRIPTION

A. General:
A distributed logic Building Automation System (BAS) complete with all software shall be provided and installed.

B. The BAS shall be provided complete and fully preprogrammed and operational with all Supervisory Software and software shall be supplied with the following features:

1. Color graphic pages for control and monitoring of BAS from on site PC, company intranet or remote Internet web browser.

2. Full client server operation capability of a minimum of 25 workstations.

3. Comprehensive alarm handling.

4. Scheduled data logging and graphing.

5. Time and event scheduling.

6. Multi level security system

7. Programming shall be object oriented using control function blocks supporting DDC functions.

8. Self-learning of controllers of all local networks.

9. Third party software interface capability.

C. Color Graphic Software:
The Supervisory Software shall run on an industry standard PC. The supervisory software shall provide the user with 3D dynamic color graphic screens displaying at the workstations, real time data from the BAS field IO points. Display diagrams of major mechanical systems with one per page shall be provided. A mouse shall be used to move pointer arrow to desired item for selection of new display or to allow operator to make changes to object data. Icon buttons or bitmaps shall provide access to other screens, make adjustments to parameters, command custom sequences or events, view graphs of live point data and calculations, and provide other custom screens of information. Provide a tool to organize pages into folders into a menu tree format so that they can be quickly located and displayed. The security system shall enable or disable access to particular pages of data so that users are only presented with information that they are authorized to see.
The supervisory software shall display and configure the following:
   1. Each connected point, status conditions, and analog values with engineering units. (F, %RH, KWH, etc.)
   2. 3 dimensional schematics and animations to make graphical interface more intuitive.
   3. All calculated parameters as specified.

4. Icons, push buttons, and adjustable set points.
5. Sequence of operation, programming logic.
6. Time schedules.
7. Data Logs, Trend Logs and Graphs.
8. Alarm conditions and messages.
9. Schematic diagrams of mechanical and electrical systems.

D. Full client server operation:
The supervisory software shall provide access to screens to a minimum of 25 client PC workstations at one time over a TCP/IP network. Clients shall have access using a standard web browser, displaying any of the color graphic pages from the Color Graphics Software subject to the individual user's access code and security setting. A page displayed in a web browser on the client workstation shall have the same view and capabilities as the page on the server workstation. The user may make adjustments, view graphs, move from page to page, enter configuration mode on a device, or carry out other actions in a similar way to working on the server workstation. Client machines shall not require any additional software other than an industry standard web browser such as Microsoft Internet Explorer.

E. Comprehensive Alarm Handling:
Upon initiation of an alarm event, the supervisory software shall provide an alarm icon on all pages that flashes and a customized message box is displayed that alerts the user of any actions required to be taken for that particular alarm. The viewer shall have filtering and sorting capability so that only the alarms in which the user is interested in shall be displayed. Information about the alarm, including the description entered by the user who acknowledged it, can be displayed. If alarm logging is enabled, each alarm shall be logged to the Supervisory software's alarm database. A logged alarm can be viewed and or queried. Alarms may be retransmitted to a network device, a workgroup, a pager, or sent via email or fax using a forwarding action. The user shall be able to create actions to be performed when alarms or groups of alarms occur. Alarms shall be grouped by location and

type.

F. Recording of logged data:
Real-time input output point data or virtual point data that is logged in a controller shall also be stored by the Supervisory Software in a permanent database for later retrieval. Data transfer of logs can be initiated manually or automatically.

G. Multi Level Scheduled Start-Stop:
Supervisory Software shall provide grouping of equipment in time zones that share the same occupancy times. Exceptions to normal workday can be set along with holidays. Supervisory software shall automatically download schedules to controllers and if required adjusted.

H. Multi Level Security:
Supervisory Software shall include as part of the security, multi level passwords for each individual logging onto the system. The Supervisory Software shall display only data authorized and workstation location for that security level. Security shall be enforced at all workstations. Each user shall be designated to a user group. Each real or virtual data point shall be designated a security level. The Master user security display shall show all user workgroups, members and access capability and point security information. Logging on to the supervisory master displays the options that apply to the particular users authority and access rights.

1. Provide additional Supervisor Security Software to include database password protection, password expiry times, failed password entry to lock user, minimum password length, and Mean Kinetic Temperature calculation to assist with compliance to the FDA regulation 21 CFR Part 11. The additional Supervisor Security Software shall provide an audit trail for all adjustments that effect system performance.

I. Display Data Graphs:
Supervisory Software shall provide for creation and display of multi-trace graphs of real time, logged, or recorded information from the input/ output points or virtual points. The graphs shall be displayed or printed, with zoom in of the coordinates selected by the operator.

J. Programming:
Supervisory Software shall provide an object oriented programming tool for creating graphics and engineering. The Objects shall be selected from a library, dragged and dropped onto the screen. The attributes of the objects then dropped into them. Programming shall be carried out on or off line.

K. Self Learning System:
Supervisory Software shall learn the controller network database that is connected without operator or engineering input. It shall then display all real time or virtual input / output point data, adjustments, time schedules, current alarms, logs.

L. Auto Dial Connection to Remote Sites:
Supervisory Software shall provide autodial to remote sites via telephone. Once connection is made it shall learn the remote site database as described above.

M. Documentation:
Supervisory Software shall provide a help file in PDF format for viewing and printing. The documentation shall cover all aspects of operation, programming and hardware of the system.

N. Controller Configuration Mode:
The Supervisory Software display shall provide a map for easy device selection. Supervisory Software shall provide access to field controllers in configuration mode for changing parameters.

O. Integration Compatibility:
Supervisory Software shall display all devices on the network connected via direct connect, Lans, Internet works, and autodial links. Supervisory Software shall display all I/O data points located in the field devices. Supervisor software shall display I/O data points from third party field devices connected via Micro-Soft OPC server software or connected via hardware drivers bridging between different protocol networks. Supervisor Software shall display all I/O point data from these third party networks and allow for integration into sequences of control, graphics, time schedules, overrides, alarms, trends, and other capabilities of the Supervisory Software.

P. Mobile Display Software:

Provide Mobile Display Software to run on a Microsoft Pocket PC that provides an interface to the BAS system enabling monitoring and adjustment of parameters within BAS and BAS controllers. The Mobile Display Software may be connected to the BAS network via a standard network connection, via a modem, or over Ethernet. The Mobile Display Software will communicate with one controller at a time, and shall display information about the occupation times, device address, and the current value of sensors, digital inputs, knobs, switches, and drivers within the controller. If required, knobs, switches, and occupation times may be adjusted. Sensors logged in the controller may be graphed, and if required, the graphs saved to file.

2.03 CENTRAL PLANT AND AIR HANDLER CONTROLLER HARDWARE:

A. General:
Provide one or more application controllers for each air handler and application controllers as needed for central plant control that adequately cover all IO points listed in point list. Controllers shall include input, output and self-contained logic program as needed for complete control of units. Controllers shall be fully programmable using graphical programming blocks. Programming tool

shall be resident on operator workstation or portable.

B. Controller Hardware:
Controllers shall be supplied in rated enclosures. All power shall be 24VAC or DC. The controller shall be provided with thermally protected transformers and solid-state multi-fuse. Controllers shall have LED indicators for transmit and receive signal, and transmit at a minimum of 19K baud. Controller shall connect directly to the Ethernet network without the need for master network controller panels.

C. Controllers Input and Output Capabilities:
Controllers shall include universal inputs with minimum 12-bit resolution that accept 3K and 10K thermistors, 0–10VDC, 0–5 VDC, 4–20 mA and dry contact signals. Inputs on a controller shall be either analog or digital with a minimum of 3 inputs that accept pulses. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller that include binary and analog outputs on board shall be selectable as either 0–10VDC or 0–20mA. Software shall include scaling features for analog outputs.

D. Controllers Communication:
Controllers shall be connected to other devices via the network. The data within controllers shall be accessible using the supervisor software or passed to other controllers peer to peer. Data shall be shared across the entire network unidirectional. Failure of a controller shall institute an orderly shutdown of the failed controller. Startup shall institute a validation check by controller before commencing control. Failure shall be reported by the next nearest on line controller. Controller power down shall not affect the network.

1. Provide additional controller communication via Touch Screen Displays that provide a self configuring user interface with the BAS. Display software shall present the user with the familiar Windows operating environment. System access shall be provided via a navigator tree, enabling controller selection, access to modules, graphs, alarms, and timezones. Each Touch Screen Display must be

configurable for access rights up to 8 individuals and must communicate with controllers on local or remote networks.

E. Additional Controller Requirements
Each controller shall have 10MB Ethernet and no other LAN connection. Each controller must have a built-in web-server with graphics built-in to the controller as well as the program. Interface to the controllers shall be via Internet Explorer with all adjustments being made from a web browser. All time schedules must reside in the controller and each controller must be able to stand alone in case of network failure. Each controller must have a minimum of 16MB of SDRAM and 8 MB of flash memory. Each controller will have a minimum of 10 universal inputs and 6 analog outputs and must be expandable to a maximum of 96 points. Each controller's expansion modules must have the capability of being mounted up to 33 feet from controller. Each Controller must have built-in Username and Password Security.

F. BACnet Communication:
Provide PC based BACnet software compliant with the standard BACnet PICS(Protocol Information Conformance Statement). The BACnet software application shall act as both client and server for integrating the BAS system with other BACnet devices, and with BACnet MMI's. The client behaviour of the software shall provide the ability to read and write from BACnet devices. The BACnet software shall initiate the read and write operations, which the remote BACnet devices respond to. Data shall then be transferred to the BAS controllers according to the software configuration. The server behaviour of the software shall allow BACnet client's (e.g. BACnet supervisors) the ability to read and write data from the BACnet software, and from the BAS controllers.

2.04 CENTRAL PLANT AND SYSTEM CONTROLLER PROGRAMMING:

A. Fixed Application Control Strategies:
Controller shall be capable of providing control strategies for system based on information from any or

all connected inputs. . Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site via simple download are not acceptable. Program execution of controller shall be a minimum of once per second.

E. Programming Sequences:
All program sequences shall be stored on board controller in EEPROM or battery backed RAM. Controllers shall operate stand-alone without connection to the network or master controllers. Data logging shall be resident in controllers with a minimum of 1000 data values per point. Controller shall execute all program sequences 1 times per second and capable of multiple PID loops for control of multiple devices. All calculations shall be completed using floating-point math and system shall support display of all information in floating-point nomenclature at operator's terminal. Programming of controller shall be completely modifiable in field over installed LANs, direct connect or network plug in engineering tools or remotely via modem interface. Operator shall program logic sequences by drag and drop function blocks on screen and tying blocks together on screen. Controller shall be programmed using supervisory software as described in software section above via the network or via a direct connect port. Controller programming strategy files shall be either uploaded or downloaded for use or storage.

B. Viewing in Real Time:
Provide means to graphically view inputs and outputs to each program block in real-time as program is executing. This function shall be performed via operator's terminal or field tool.

C. Battery:
Controller shall have adequate data storage to ensure high performance and data reliability. Battery shall retain static RAM memory and real-time clock functions for a minimum of 5 years (cumulative). Battery shall be a field-replaceable (non-rechargeable) lithium cell type.

D. Clock Support:
Onboard, battery-backed real time clock must support

schedule operations and trend logs.

E. Processor:
Global control algorithms and automated control functions shall be execute via a minimum 16-bit processor.

F. Communication:
Controller shall include both on-board 10BASE-T Ethernet communication over twisted pair cable (UTP) and shall include IP communication.

G. Electrical Requirements:
All outputs must have onboard Hand-Off-Auto switches and a status indicator light. HOA switch position shall be monitored. Each analog output shall include a potentiometer for manually adjusting output when HOA switch is in Hand position.

H. Display Panel at Controller:
The controller shall have an optional display panel for access to the entire network for making modifications to the time schedules, set points, view alarms, and viewing logs.

2.05 TERMINAL UNIT OPEN & FIXED APPLICATION CONTROLLERS

A. General:
Provide application controller for each piece of unitary mechanical equipment that adequately covers all points listed in point list for unit. All controllers shall interface to system via network. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.

1. Terminal Unit Open and Fixed Application Controllers shall support communication with other LON and LonMark devices over a LonWorks network.

B. Application Controllers:
Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0-10 VDC, 4–20 mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller shall be either analog or digital. Controller shall also

include support and modifiable programming for interface to room sensor. Controller shall include binary outputs on board with analog outputs as needed.

C. Storage:
All program sequences shall be stored on board controller in EEPROM or battery backed RAM. All program sequences shall be executed by controller 1 times per second and shall be capable of PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in field over installed LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen or configuring fixed application software resident in controller. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.

D. Display:
Application controller shall include support for room sensor. Display on room sensor shall temperature, override button and Setpoint adjust dial. See sequence of operation for specific display requirements at intelligent room sensor.

E. Flow Sensor:
Application controller shall include microprocessor driven flow sensor for use in pressure independent control logic. All boxes shall be controlled using pressure independent control algorithms and all flow readings shall be in CFM (LPS if metric).

E. Calibration:
On board flow sensor shall be microprocessor driven and precalibrated at factory. All factory calibration data shall be stored in EEPROM. Calibration data shall be field adjustable to compensate for variations in VAV box type and installation. Operator workstation, portable computers and special hand-held field tools shall be provided if needed for field calibration.

G. Temperature Sensor:
Provide as specified a duct temperature sensor at discharge of each VAV box that is connected to controller for reporting back to operator workstation.

H. Outstation Display Panel Operator Terminal:

1. LCD operator terminal is a small wall- or panel-mounted operator terminal that connects directly to LAN. Each operator terminal shall be able to display any object from anywhere in network.

2. Each of these operator's terminals shall have a keypad and an adjustable backlit LCD, with a simple menu structure to give occupants and technicians intuitive access to system information. It shall have a minimum 4-line by 20-character display to allow an operator to query and adjust system values.

I. Field Service Tool:

1. Field service tool shall allow technician to view and modify all set points and tuning parameters stored in application controller. In addition, technician shall be able to view status of all inputs and outputs on digital readout.

2. Field service tool shall plug into wall sensor and provide all functionality specified. Operator workstation shall include capability to disable operation of field service tool.

J. (Network Connection Tool)

1. Network connection tool shall allow technician to connect a laptop to any network or at any device and view and modify all information throughout entire network. Laptop connection to tool shall be via Ethernet or PTP.

2. Provide quick connect to MS/TP LAN at each controller. Tool shall be able to adjust to all MS/TP baud rates specified in BACnet standard.

3. Provide **[1]** Network Connection Tools for this project.]

2.06 SENSORS

A. Temperature Sensors:
Provide as specified sensors connected to controllers for reporting back to operator workstation.

1. Duct temperature:
   a. Temperature monitoring range: +20/120°F.
   b. Accuracy at Calibration point: ±0.5°F.

2. Duct Average temperature:
   a. Temperature monitoring range: +20°±120°F.
   b. Accuracy at Calibration point: ±0.5°F.
   c. Sensor Probe Length: 25’.

3. Outside air temperature:
   a. Temperature monitoring range: 58°±122° F.
      1. Accuracy at Calibration point: ±0.5°F

4. Room temperature:
   a. Temperature monitoring range: +50/90°F.
   b. Accuracy at Calbration point: ±0.5°F.
   c. Plane white cover w/ setpoint adjusment and override.

5. Pressure to Current Transducer:
   a. Provide as specified sensors connected to controllers for reporting back to operator workstation.
      2. Accuracy: ± 1% of full scale.

5. Immersion Temperature Sensor:
   i. Provide as specified sensors with immersion well, stainless or copper connected to controllers for reporting back to operator workstation.
   ii. Temperature range of 35 to 90F for cold water and 80 to 250 for hot water.
   Accuracy: ± .5F

C. Actuator
Electric control actuation shall utilize direct-coupled actuators. Belimo, or approved equal.

Damper actuators shall be Brushless DC Motor Technology with stall protection, bi-directional, fail safe spring return, all metal housing, manual override, independently adjustable dual auxiliary switch.

1. Actuator assembly shall include necessary hardware and proper mounting and connection to a standard ½" diameter shaft or damper blade.

2. Actuators shall be designed for mounting directly to damper shaft without need for connecting linkages.

3. All actuators having more than 100 lb-in torque output shall have a self-centering damper shaft clamp that guarantees concentric alignment of actuator's output coupling with damper shaft. Self-centering clamp shall have a pair of opposed "v" shaped toothed cradles, each having two rows of teeth to maximize holding strength. A single clamping bolt shall simultaneously drive both cradles into contact with damper shaft.

4. All actuators having more than a 100 lb-in torque output shall accept a 1" diameter shaft directly, without need for auxiliary adapters.

5. All actuators shall be designed and manufactured using ISO900registered procedures, and shall be listed under Standards UL873 and CSA22.2 No. 24-93 l.

6. Actuators shall be manufactured by Honeywell.

D. Automatic Control Valves:

1. Modulating Two Way Type - Valves shall be provided with equal percentage contoured throttling plugs. Three way valves shall be provided with linear throttling plugs such that total flow through valve remains constant regardless of valve position. Valves 2.00 inches and smaller shall be cast brass body with threaded connections. Valves 2.50 inches and larger shall be cast iron body with flanged connections. Valves shall be capable of withstanding

maximum operating pressures and temperatures of controlled medium with tight shut-off capability. Minimum valve body pressure rating shall be 125 psig. Valves controlling steam with an inlet pressure of 25 psig or greater shall be equipped with stainless steel trim. Unless indicated otherwise, maximum pressure drop across control valve at design flow is 5 psig for water systems. Actuators shall be selected to close valve under flow conditions against 150% of normal control medium operating pressure. [Electric valve actuators shall be of non-stall type and shall de-energize when valve has reached operator or system controlled position. Valve actuator shall provide full linear position feedback for full range of actuator movement. Feedback status shall be monitored from central or remote operator's terminal and be displayed in percent open notation. Systems that provide only end switch feedback are not acceptable.] Valves larger than 0.75 inches shall be provided with valve-stem travel indicators as a means of indicating position of valve. [Where sequencing of valves is required, provide positive position relays.] Reheat terminal control valves shall be normally open.

2. Two-Position Type - Full line size threaded lug type butterfly valve, full line size 2-piece ball valve, or modulating type valve as specified above with a maximum pressure drop at design flow of 1 psig. Valves shall be capable of withstanding maximum operating pressures and temperatures of controlled medium with tight shut-off capability. Minimum valve body pressure rating shall be 125 psig. Actuators shall be selected to close valve under flow conditions against 150% of normal control medium operating pressure. All valves shall be provided with an externally visible means of position indication. Normally open and normally closed designations on Drawings refer to valve position under normal operating conditions.

3. Valves shall be manufactured by Honeywell.

Positioning Relays:

Provide positioning relays on pneumatic actuators, where required, to provide sufficient power, sequencing, repeatability, or speed of response.

E. Automatic control dampers (ACD)

1. General:
Individual damper blades shall be a maximum of 6.00 inches wide and/or 4.00 feet long. Edge seals shall be suitable for 0°F to 180°F operating temperatures. Blade linkages shall be attached at mid-point of blade length. Provide actuators as required for application. Provide one actuator for every 20 sq.ft. Of damper Actuators shall utilize spring return on all outside air applications. Provide positioning relays on pneumatic actuators, where required, to stroke damper(s) properly (i.e., sufficient power, sequencing, repeatability, or speed of response).

F. Electronic and Electric Devices:

Freeze Thermostat.

a. Electric low temperature switch with manual reset, adjustable set point 15°F to 55°F, and sensing element. A 20.00-ft long non-averaging sensing element shall activate switch whenever any 1.00-ft section or more of any section senses a temperature as low as thermostat set point. Provide two contacts, one for fan shutdown and one for control system alarm.

6. Air Differential Pressure Switches.

a. Diaphragm actuated switch with adjustable set point fixed differential, automatic reset, and angle tipped static pressure probes. Range as required, 12.00-inch maximum operating differential.

7. Fluid Differential Pressure Switch.

a. Diaphragm actuated switch with adjustable set

point and differential range as required, 200-psi maximum operating differential.

8. Liquid Flow Switch.
   a. Paddle type, 150 psig maximum working pressure, and flow actuation sensitivity as required for application.

9. Current Switch/Sensor.
   a. Solid state relay which senses AC current and outputs a DC current suitable for either a DDC digital input or analog input, as required for application.

10. Time Clock.
   a. 120 volt electrically powered, mechanically driven 7-day, 24-hour per day time clock with 10-hour minimum battery backup, number, and type of contacts, as required.

11. Duct Smoke Detector.
   a. Shall be stand-alone, sampling photoelectric type for sensing of products of combustion within air stream of ducted fan systems. Devices shall include necessary sampling tube extensions and sensitivity adjustments for detecting products of combustion across width of duct. Device shall function uniformly in air velocities of 400 fpm through 3,000 fpm. Voltage shall be 24 volts DC or 120 volts AC. Include 2 sets of auxiliary contacts rated for 12 amps resistive with manual reset. Visual indication of normal and alarm/trouble conditions shall be incorporated into exposed surface of device.

12. By-Pass Timer.
   a. Zero to six-hour dial type electro-mechanical timed switch. Intermatic, or reviewed equivalent.

13. Differential Pressure Transducers.
   a. Shall vary output voltage with changes in sensed differential pressure. Sensor shall have an end-

to-end accuracy of not less than ±1% of span including non-linearity and hysteresis.

14. Air Static Pressure Sensors.
    a. Solid state, 24-vac input that shall vary output voltage with changes in sensed static pressure. Sensor shall have an end-to-end accuracy of ±1% of span or better including non-linearity and hysteresis.

15. Status type Current Sensors.
    a. Shall vary output voltage proportional to change in sensed current. Multiple range units shall be provided to allow for varying site conditions. Low range units shall offer ranges of 10, 20, and 50 amps. High range units shall offer ranges of 50, 100, and 200 amps. Provide actual analog current indication for status of all motors one horsepower and larger. Provide switch points to determine motor status in software.

16. Low Temp Detectors.
    a. Provide double pole, single throw, and manual reset low temperature detectors for each air handler containing a chilled water coil. Locate such that an accurate cross-section of duct is sampled. Wire to motor starter to prevent operation when tripped. Wire to DDC control panel to indicate device status.

17. CO_2 Sensors.
    a. Provide an electronic sensor to monitor amount of Carbon Dioxide (CO_2) suitable for duct mounting. Measuring principal shall be based on infrared spectroscopy. Internal electronics shall require a 24 vac power supply and shall calculate CO_2 concentration in return air and output a linearized actual value of 0-5 vdc to DDC panel for use in optimization of mixing dampers and economizer control.

PART 3 EXECUTION

3.01 PROJECT MANAGEMENT

A. General:
Provide a designated project manager who will be responsible for following:

1. Construct and maintain project schedule.

2. On-site coordination with all applicable trades, subcontractors, and other integration vendors Authorized to accept and execute orders or instructions from owner/architect.

3. Attend project meetings as necessary to avoid conflicts and delays.

4. Make necessary field decisions relating to this scope of work.

5. Provide coordination/single point of contact

3.02 SEQUENCE OF OPERATION

A. General:

3.03 START-UP AND COMMISSIONING

A. General:
When installation of system is complete, calibrate equipment and verify transmission media operation before system is placed on-line. Manufacturer or his certified agents shall complete all testing, calibrating, adjusting and final field tests.

B. System Modifications:
Provide any recommendation for system modification in writing to owner. Do not make any system modification, including operating parameters and control settings, without prior approval of owner.

C. Commissioning of Integrated System Segments:
After completion of system start-up and commissioning Joint commissioning of integrated system segments shall be completed.

3.04 ELECTRICAL WIRING AND MATERIALS

A. General:
Install, connect and wire items included under this Section. This work includes providing required conduit, wire, fittings, and related wiring accessories. All wiring shall be installed in conduit.

B. Wiring:
Provide wiring between thermostats, [aquastats,] [unit heater motors,] and all control and alarm wiring for all control and alarm devices for all Sections of Specifications.

C. Emergency Power:
[Provide 120 volt, single phase, 60 hertz emergency power to every B.M.S. DDC Controller panel, HVAC/Mechanical Equipment Controller, PC console, power supply, transformer, annunciator, modems, printers and to other devices as required. It is intent that entire building management system except terminal equipment shall be operative under emergency power conditions in building. Power supplies are to be extended in conduit and wire from emergency circuit breakers.]

D. Conduit and Wiring:

1. Provide status function conduit and wiring for equipment covered under this Section.

2. Provide conduit and wiring between B.A.S. panels and temperature, humidity, or pressure sensing elements, including low voltage control wiring in conduit.

3. Provide conduit and control wiring for devices specified in this Section.

4. Provide conduit and signal wiring between motor

starters in motor control centers and high and/or low temperature relay contacts and remote relays in B.M.S. panels located in vicinity of motor control centers.

5. Provide conduit and wiring between PC workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contractors, and B.M.S. panels, as shown on drawings or as specified.

6. All wiring to be compliant to local building code and NEC.

7. Provide electrical wall box and conduit sleeve for all wall-mounted devices.

3.05 PERFORMANCE

A. General:
Unless stated otherwise, control temperatures within plus or minus 1^{o}F, humidity within plus or minus 5% of set point and static pressure within 10% of set point.

3.06 COMMISSIONING, TESTING AND ACCEPTANCE

A. General:
Perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets, which shall be submitted prior to acceptance testing. Commissioning work, which requires shutdown of system or deviation from normal function, shall be performed when operation of system is not required. Commissioning must be coordinated with owner and construction manager to ensure systems are available when needed. Notify operating personal in writing of testing schedule so that authorized personnel from owner and construction manager are present throughout commissioning procedure.

1. Prior to system program commissioning, verify that each control panel has been installed according to

plans, specifications and approved shop drawings. Test, calibrate and bring on line each control sensor and device. Commissioning to include, but not be limited to:

a. Sensor accuracy at 10, 50 and 90% of range.
b. Sensor range.
c. Verify analog limit and binary alarm reporting.
d. Point value reporting.
e. Binary alarm and switch settings.
f. Actuator ranges.
g. Fail safe operation on loss of control signal, electric power, and network communications.

B. Operational System Demonstration:
After control devices have been commissioned (i.e. calibrated, tested and signed off), each BAS program shall be put on line and commissioned. Contractor shall, in presence of owner and construction manager, demonstrate each programmed sequence of operation and compare results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy's. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between specification and actual performance will be immediately rectified and retested.

C. System Performance Verification:
After all BAS programs have been commissioned, contractor shall verify overall system performance as specified. Tests shall include, but not be limited to:

1. Data communication, both normal and failure modes.

2. Fully loaded system response time.

3. Impact of component failures on system performance and system operation.

4. Time/Date changes.

5. End of month/ end of year operation.

6. Season changeover.

7. Global application programs and point sharing.

8. System backup and reloading.

9. System status displays.

10. Diagnostic functions.

11. Power failure routines.

12. Battery backup.

13. Smoke Control, stair pressurization, stair, and vents, in concert with Fire Alarm System testing.

14. Testing of all electrical and HVAC systems with other divisions of work.

D. Acceptance Test Procedure:
Submit for approval, a detailed acceptance test procedure designed to demonstrate compliance with contractual requirements. This Acceptance test procedure will take place after commissioning procedure but before final acceptance, to verify that sensors and control devices maintain specified accuracy's and system performance does not degrade over time.

E. Point and Function Demonstration:
Using commissioning test data sheets, contractor shall demonstrate each point. Contractor shall also demonstrate all system functions. Contractor shall demonstrate all points and system functions until all devices and functions meet specification.

F. Instruments for Testing:
Contractor shall supply all instruments for testing [and turn over same to owner after acceptance testing].

1. All test instruments shall be calibrated and submitted (cut sheets, data charts, or descriptions) for approval with copies of calibration records.

2. Test Instrument Accuracy:
   a. Temperature: 1/4F or 1/2% full scale, whichever is less.
   b. Pressure: High Pressure (psi): ½ psi or 1/2% full scale, whichever is less.
   c. Low Pressure: 1/2% of full scale (in w.c.).
   d. Humidity: 2% RH.
   e. Electrical: 1/4% full scale.

G. Performance Period:
After above tests are complete and system is demonstrated to be functioning as specified, a thirty-day performance test period shall begin. If system performs as specified throughout test period, requiring only routine maintenance, system shall be accepted. If system fails during test, and cannot be fully corrected within eight hours, owner may request that performance tests be repeated.

3.07 TRAINING

A. Instructor:
Manufacturer shall provide factory-trained instructor to give full instruction to designated personnel in operation of system installed. Instructors shall be thoroughly familiar with all aspects of subject matter they are to teach. Manufacturer shall provide all students with a student binder containing product specific training modules for system installed. All training shall be held during normal working hours of 8:00 am to 4:30 PM weekdays.

B. Duration:
Provide [_ hours] of training for Owner's designated operating personnel. Training shall include:

C. [Additional Training:
Provide a one-week training course at manufacturers' factory on basic system operations and functionality. Include all airfare, meals and hotel costs as well as factory registration costs for one individual.]

D. Provide:

1. Explanation of drawings, operations and maintenance manuals.

2. Walk-through of job to locate control components Operator workstation and peripherals.

3. DDC controller and ASC operation/function.

4. Operator control functions including graphic generation and field panel programming.

5. Operation of portable operator's terminal.

6. Explanation of adjustment, calibration and replacement procedures.

7. Student binder with training modules.

   i. System log-on procedures.

   ii. Review of sequence of operations.

   iii. System troubleshooting.

   iv. Emergency service interface

   v. Fire alarm interface.

   vi. System restart after power failure.

   vii. System backup and restoration procedures.

   viii. Replacement procedures of each system component.

   ix. Calibration and initialization procedures.

17. Regeneration procedures on all installed programming at operator’s control stations.

18. Operation of maintenance service programs.

3.08 POINT SCHEDULE MATRIX - I/0 SCHEDULE

A. General:

1. Following points, as defined for each piece of equipment, are designated as follows:
   a. Binary Out (BO) - Defined as any two-state output (start/stop) (enable/disable), etc.
   b. Binary In (BI) - Defined as any two-state input (alarm, status), etc.
   c. Analog In (AI) - Defined as any variable input (temperature) (position), etc.
   d. Analog Out (AO) - Defined as any electrical variable output. 0–20mA, 4–20mA and 0–10VDC are only acceptable analog outputs. Driver for analog outputs must come from both hardware and software resident in controllers. Transducers will not be acceptable under any circumstance.

END OF SECTION