

SECTION 23 90 40

BUILDING AUTOMATION SYSTEM

PART 1 GENERAL

1.01 SCOPE OF WORK:

- A. The Building Automation System (BAS) manufacturer shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems as herein specified. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer.
- B. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specially for this project. All systems and components shall have been thoroughly tested and proven in actual use for at least two (2) years.
- C. BAS manufacturer shall be responsible for all BAS and Temperature Control wiring for a complete and operable system. All control wiring required for this installation is included in this contract and shall be color coded. All control wiring shall be in conduit. Conduit, wiring sizes, and type of insulation shall be in accordance with DIVISION 26 - ELECTRICAL, and shall conform to the latest issue of the National Electrical Code. All electrical equipment shall bear UL labels. Each control circuit shall be protected by a circuit breaker of the proper size.

1.02 WORK BY OTHERS

- A. Mechanical Contractor installs all, duct mounted smoke detectors furnished by the electrical contractor.
- B. Electrical Contractor provides
 - 1. Wiring of all power feeds through all disconnects and starters to electrical motors.
 - 2. Duct mounted smoke detectors
 - 3. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by BAS manufacturer.

1.03 RELATED WORK

- A. General and Special Conditions
- B. Mechanical
- C. Electrical

1.04 QUALITY ASSURANCE:

- A. The BAS system shall be designed, installed, commissioned and serviced by factory trained personnel. Manufacturer shall have an in-place support facility within 100 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment.
- B. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

- C. BAS shall comply with UL 916 PAZX and 864 UDTZ, European Community, and other subsystem listings as applicable, and herein specified, and be so listed at the time of bid.
- D. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
- E. The manufacturer of the building automation systems shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.
- F. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels and extend new field panels on a previously installed network.

1.05 SUBMITTALS:

- A. Submit 10 complete sets of documentation in the following phased delivery schedule:
 - 1. Equipment data cut sheets
 - 2. System schematics, including:
 - a. Sequence of Operations
 - b. Point Names
 - c. Point Addresses
 - d. Interface Wiring Diagrams
 - e. Panel Layouts
 - f. System Riser Diagrams
 - 3. Auto-CAD compatible as-built drawings.
- B. Upon project completion, submit operation and maintenance manuals, consisting of the following:
 - 1. Index sheet, listing contents in alphabetical order.
 - 2. Manufacturer's equipment parts list of all functional components of the system, Auto-CAD disk of system schematics, including wiring diagrams.
 - 3. Description of sequence of operations.
 - 4. As-built interconnection wiring diagrams.
 - 5. Operator's Manual.
 - 6. Trunk cable schematic showing remote electronic panel locations, and all trunk data.
 - 7. List of connecting data points, including panels to which they are connected and input device (ionization detector, sensors, etc.)
 - 8. Conduit routing diagrams.

1.06 WARRANTY:

- A. Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of one year after beneficial use.
- B. The adjustment, required testing, and repair of the system includes all computer equipment,

transmission equipment and all sensors and control devices.

- C. This specification requires that for **1 year**, the Myrtle Beach Convention Center will have 24/7/365 monitoring of *up to 50* of their most critical alarms from a dedicated remote facility staffed with HVAC technical specialists. The Original Equipment Manufacturer (OEM) Monitoring center must have full redundancy in systems at the data center level to fully support a 24/7/365 operation. This includes, but is not limited to, the following systems: electrical, phone, database, and support. The center must have a staff of controls specialists with field expertise in HVAC applied systems operations. Facility controls specialists must be factory-trained and certified in Building Automation Systems (BAS). In the event of an outage at the primary remote center, a redundant site must be in place to provide additional backup and support. To ensure quality, the center must have shift supervisors available for any escalated measures 24/7/365. Furthermore, all telephone interactions with monitoring facility must be recorded. It will be the responsibility of the building owner to provide the connectivity medium required for remote monitoring to the DDC contractor, as well as the annual costs of maintaining that medium (*for example, phone line, internet, et cetera*). The ability to connect remotely is contingent on receiving permission for remote access from property owner. Upon receipt of an alarm through an owner-provided connectivity medium (*such as a phone line or internet access*), the DDC contractor must provide automatic support by routing its notification directly (*with a time-and-date stamp*) from a remote monitoring facility to a chosen representative of the Myrtle Beach Convention Center by means of e-mail, text message, or pager for immediate response. To guarantee continual monitoring, communication between the remote monitoring facility and the Myrtle Beach Convention Center building control system must be tested and proven each *quarter*. A record of this successful test, as well as a record of each automated critical alarm recorded and sent to the Myrtle Beach Convention Center, must also be delivered each quarter. The remote facility must compile and store a history of all critical alarms (*with this data being the owned property of the remote monitoring service provider*) for further redundancy and protection from failures. During start-up and commissioning of the alarm reporting, the Myrtle Beach Convention Center may trip an alarm to demonstrate remote capability prior to acceptance.
- D. If the problem cannot be resolved with on-line support services, the BAS manufacturer shall dispatch the appropriate personnel to the job site to resolve the problem within three (3) hours of the time that the problem is reported.

PART TWO - PRODUCTS:

2.01 ACCEPTABLE MANUFACTURER:

- A. System shall be manufactured by Johnson Controls.

2.02 NETWORKING COMMUNICATIONS:

- A. The design of the BAS shall network operator workstations and stand-alone DDC Controllers. The network architecture shall consist of two levels, a high performance peer-to-peer building level network and DDC Controller floor level local area networks with access being totally transparent to the user when accessing data or developing control programs.
- B. The design of BAS shall allow the co-existence of new DDC Controllers with existing DDC Controllers in the same network without the use of gateways or protocol converters.
- C. Peer-to-Peer Building Level Network:
1. All operator devices either network resident or connected via dial-up modems shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. No

hardware or software limits shall be imposed on the number of devices with global access to the network data at any time.

2. The network shall support a minimum of 100 DDC controllers and PC workstations.
3. Each PC workstation shall support a minimum of four (4) peer-to-peer networks hardwired or dial up.

2.03 DDC CONTROLLER FLOOR LEVEL NETWORK:

- A. This level of communication shall support a family of application specific controllers and shall communicate with the peer-to-peer network through DDC Controllers for transmission of global data. Provide a web browser user interface. There shall be no vendor-proprietary software required to be installed on user PCs.

2.04 DDC CONTROLLER:

- A. DDC Controllers shall be 16-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input-output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point I/O schedule. Each controller shall support a minimum of three (3) Floor Level LAN Device Networks.
- B. Each DDC Controller shall have sufficient memory to support its own operating system and databases, including:
 1. Control processes
 2. Energy management applications
 3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
 4. Historical/trend data for points specified
 5. Maintenance support applications
 6. Custom processes
 7. Operator I/O
 8. Dial-up communications
 9. Manual over-ride monitoring
- C. Each DDC Controller shall support firmware upgrades without the need to replace hardware.
- D. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
- E. DDC Controllers shall provide a minimum two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.
- F. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at by software override point digital control type points and gradual switches for analog control type points.
 1. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override

activity information for reports.

- G. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.
- H. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
- I. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.
- J. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.
 - 1. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.
 - 2. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.
- K. Provide a separate DDC Controller for each AHU or other HVAC system as indicated in Section 3.02, Sequence of Operation. It is intended that each unique system be provided with its own point resident DDC Controller.

2.05 DDC CONTROLLER RESIDENT SOFTWARE FEATURES:

- A. General:
 - 1. The software programs specified in this Section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution.
 - 2. All points shall be identified by up to 30 character point names and 16 character point descriptors. The same names shall be used at the PC workstation.
 - 3. All digital points shall have user defined two-state status indication (descriptors with minimum of eight [8] characters allowed per state (i.e. summer/winter)).
- B. Control Software Description:
 - 1. The DDC Controllers shall have the ability to perform the following pre-tested control algorithms:
 - a. Two-position control
 - b. Proportional control
 - c. Proportional plus integral control
 - d. Proportional, integral, plus derivative control

- e. Automatic tuning of control loops.
- C. DDC Controllers shall have the ability to perform any or all the following energy management routines:
- 1. Time-of-day scheduling - up to a year in advance
 - 2. Calendar-based scheduling
 - 3. Holiday scheduling
 - 4. Temporary schedule overrides
 - 5. Start-Stop Time Optimization (automatically coordinated with TOD scheduling)
 - 6. Automatic Daylight Savings Time Switchover
 - 7. Night setback control
 - 8. Enthalpy switchover (economizer)
 - 9. Peak demand limiting
 - 10. Temperature-compensated duty cycling.
- D. DDC Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
- 1. A single process shall be able to incorporate measured or calculated data from any and all other DDC Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network. Database shall support 30 character, English language point names, structured for searching and logs.
 - 2. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
 - 3. DDC Controller shall provide a HELP function key. Enhanced context sensitive on-line help with task orientated information from the user manual.
 - 4. DDC Controller shall be capable of comment lines for sequence of operation explanation.
- E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controller's ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
- 1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
 - 2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six (6) priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
 - 3. Alarm reports and messages will be directed to a user-defined list of operator devices

or PCs based on time (after hour's destinations) or based on priority.

4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
 5. In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.
- F. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the I/O summary.
1. Any point, physical or calculated, may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controller's point group. Two (2) methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of one (1) minute to seven (7) days shall be provided. Each DDC Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples. All trend data shall be available for use in third-party personal computer applications (i.e. Microsoft Excel, Lotus 123).
 2. DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary.
 - a. Loop tuning shall be capable of being initiated either locally at the DDC Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.
- G. DDC Controllers shall be capable of automatically accumulating and storing run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O schedule.
- H. The peer-to-peer network shall allow the DDC Controllers to access any data from or send control commands and alarm reports directly to any other DDC Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC Controllers shall send alarm reports to multiple workstations without dependence upon a central or intermediate processing device. The peer-to-peer network shall also allow any DDC Controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.
- I. The peer-to-peer network shall allow the DDC controllers to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control the points that the operator is authorized for. All other points shall not be displayed on the PC workstation or portable terminal (e.g. all base building and all tenant points shall be accessible to any base building operators, but only tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

2.06 FACTORY MOUNTED APPLICATION SPECIFIC DDC CONTROLLER: ASC

- A. Each Factory mounted DDC controller shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each Factory mounted DDC controller shall be a microprocessor-based, multi-tasking, real-time digital control processor. Provide the following types of DDC Controllers as a minimum:
- B. Variable Volume Packaged Rooftop Units
2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences.
 3. Each controller shall allow for stand-alone operation in the event communication with its DDC Controller is lost and to insure protection during power outages.
 4. Each factory Mounted DDC control panel shall have a unit mounted LCD display capable of unit configuration and monitoring the following:
 - i.) View and set date and time
 - ii) Modify and override time-of-day schedules
 - iii.) View points and alarms
 - vi.) Monitor points
 - v.) Command and modify set points.
- C. Terminal Equipment Controllers:
1. Provide for control of each piece of equipment, including, but not limited to, the following:
 - a. Variable Air Volume (VAV) Boxes
 - b. Constant Volume Packaged Rooftop Units
 2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be 24V floating control, allowing for interface to a variety of modulating actuators. Terminal controllers utilizing proprietary control signals and actuators shall not be acceptable.
 3. Each controller performing space temperature control shall be provided with a matching room temperature sensor. The sensor may be either RTD or thermistor type.
 4. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable laptop or similar operator's terminal to control and monitor all hardware and software points associated with the controller.
 5. Each room sensor shall also include the following auxiliary devices:
 - Set point Adjustment Dial
 - Temperature Indicator
 - Override Switch.
 6. The set point adjustment dial shall allow for modification of the temperature by the occupant. Set point adjustment may be locked out, overridden or limited as to time or

temperature through software by an authorized operator at the central workstation, MBC or via the portable programming tool.

7. The temperature indicator shall be a LCD thermometer and shall be visible without removing the sensor cover.
8. The override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant. The override function may be locked out, overridden or limited as to the time through software by an authorized operator at the central workstation, MBC or via the portable programming tool.

2.07 PERSONAL COMPUTER OPERATOR WORKSTATION HARDWARE:

- A. Personal computer operator workstations shall be provided for command entry, information management, network alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater fault tolerance and reliability.
 1. Provide workstation of equal capability located as indicated on plans.
 2. Workstation shall consist of 24" HD monitor with LED, personal computer with minimum 2 TB hard drive and 3.90 GHZ processor, CD/DVD burner, mouse and keyboard. PC shall be capable of performing all BAS functions efficiently. Provide with a laser printer.

2.08 WEB BASED WORKSTATION OPERATOR INTERFACE:

- A. Furnish [1] PC based operator interface as shown on the system drawings. Each of these operator interfaces shall be able to access all information in the system. The operator interface shall reside on the Enterprise wide network, which is same high-speed communications network as the System Controllers. The Enterprise wide network will be provided by the owner and supports the Internet Protocol (IP).
 1. Each PC based operator interface shall include the following:
 - a. Hardware type
 - 1) PC
 - 2) Laptop
 - b. Operating Systems
 - 1) Windows XP
 - 2) Windows 7
 - c. Minimum Hardware
 - 1) Pentium Core 2 DUO or better
 - 2) 4 GB RAM
 - 3) 100 GB hard drive space
 - 4) Internet Browser compatible with operator interface requirements outlined in the operator interface section
 - 5) Java Runtime Environment (JRE) V6.0 or higher
 2. Operator Interface
 - a. The operator interface shall be accessible via a web browser.
 - b. The operator interface shall support the following Internet web browsers:
 - 1) Internet Explorer 8.0+
 - 2) Firefox 4.0+

- 3) Chrome 10.0+
- c. The operator interface shall support the following mobile web browsers:
 - 1) iOS (iPad/iPhone) V4.0+
 - 2) Android (Tablet) V4.0+
 - 3) Android (Phone) V2.3+
- d. System Security
 - 1) Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data.
 - 2) System security shall be selectable for each operator.
 - 3) The system supervisor shall have the ability to set security levels for all other operators.
 - 4) Each operator password shall be able to restrict the operator's access for viewing and/or changing each system application, full screen editor, and object.
 - 5) Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected for a defined period of time.
 - 6) All system security data shall be stored in an encrypted format.
 - 7) There is no limit to the number of password-protected users allowed in the system.
 - 8) The system should also support flexible business rules for valid usernames and passwords.
 - 9) The system shall support state-of-the-art encryption between server and web browser.
 - 10) The enterprise system can optionally be configured to encrypt data between the client and server using SSL (128bit).
- e. Database
 - 1) Database Save. A system operator with the proper password clearance shall be able to archive the database on the designated operator interface PC.
 - 2) Database Restore. The system operator shall also be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
- f. On-Line Help and Training
 - 1) Provide a context sensitive, on line help system to assist the operator in operation and configuration of the system.
 - 2) On-line help shall be available for all system functions and shall provide the relevant data for each particular screen.
- g. System Diagnostics
 - 1) The system shall automatically monitor the operation of all network connections, building management panels, and controllers.
 - 2) The failure of any device shall be annunciated to the operators.
- h. Equipment & Application Pages
 - 1) The operator interface shall include standard pages for all equipment and applications. These pages shall allow an operator to obtain information relevant to the operation of the equipment and/or application, including:
 - a) Animated Equipment Graphics for each major piece of equipment and floor plan in the System. This includes:
 - (1) Each Chiller, Air Handler, VAV Terminal, Fan Coil, Boiler, and Cooling Tower. These graphics shall show all points dynamically as specified in the points list.
 - (2) Animation capabilities shall include the ability to show a sequence of images reflecting the position of analog outputs, such as valve or damper positions. Graphics shall be capable of launching other web pages.
- i. System Graphics. Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using colors to represent zone temperature relative to zone set point.
 - 1) Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment,

- to use point and-click navigation between zones or equipment, and to edit set points and other specified parameters.
 - 2) Graphic imagery – graphics shall use 3D images for all standard and custom graphics. The only allowable exceptions will be photo images, maps, schematic drawings, and selected floor plans.
 - 3) Animation. Graphics shall be able to animate by displaying different Image lies for changed object status.
 - 4) Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
 - 5) Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Macromedia Flash).
- j. Custom Graphics
- 1) The operator interface shall be capable of displaying custom graphics in order to convey the status of the facility to its operators.
 - 2) Graphical Navigation. The operator interface shall provide dynamic color graphics of building areas, systems and equipment.
 - 3) Graphical Data Visualization. The operator interface shall support dynamic points including analog and binary values, dynamic text, static text, and animation files.
 - 4) Custom background images. Custom background images shall be created with the use of commonly available graphics packages such as Adobe Photoshop. The graphics generation package shall create and modify graphics that are saved in industry standard formats such as GIF and JPEG.
- k. Graphics Library. Furnish a library of standard HVAC equipment such as chillers, air handlers, terminals, fan coils, unit ventilators, rooftop units, and VAV boxes, in 3-dimensional graphic depictions. The library shall be furnished in a file format compatible with the graphics generation package program.
- l. Manual Control and Override.
- 1) Point Control. Provide a method for a user to view, override, and edit if applicable, the status of any object and property in the system. The point status shall be available by menu, on graphics or through custom programs.
 - 2) Temporary Overrides. The user shall be able to perform a temporary override wherever an override is allowed, automatically removing the override after a specified period of time.
 - 3) Override Owners. The system shall convey to the user the owner of each override for all priorities that an override exists.
 - 4) Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually.
- m. Engineering Units
- 1) Allow for selection of the desired engineering units Inch pound in the system.
 - 2) Unit selection shall be able to be customized by locality to select the desired units for each measurement.
 - 3) Engineering units on this project shall be IP.
3. Scheduling. A user shall be able to perform the following tasks utilizing the operator interface:
- a. Create a new schedule, defining the default values, events and membership.
 - b. Create exceptions to a schedule for any given day.
 - c. Apply an exception that spans a single day or multiple days.
 - d. View a schedule by day, week and month.
 - e. Exception schedules and holidays shall be shown clearly on the calendar.
 - f. Modify the schedule events, members and exceptions.
 - g. Global Scheduling Support

- 1) Assign attributes for individual schedules in order to facilitate quick selection of similar schedules across multiple buildings.
 - 2) The system shall allow ability to make changes to weekly schedules of all schedules in the system through single edit action.
 - 3) Ability to apply an exception to any or all of the schedules in a system through a single edit action.
 - 4) Allow user to specify different events for each day of the week when applying exceptions to schedules.
 - 5) Allow user to enact an emergency schedule for any or all of the schedules in the system through a single click action.
4. Trend Logs
 - a. Trend Logs Definition.
 - 1) The operator interface shall allow a user with the appropriate security permissions to define a trend log for any data in the system.
 - 2) The operator interface shall allow a user to define any trend log options as described in the Application and Control Software section.
 - b. Trend Log Viewer.
 - 1) The operator interface shall allow Trend Log data to be viewed and printed.
 - 2) The operator interface shall allow a user to view trend log data in text-based (time – stamp/value).
 - 3) The operator shall be able to view the data collected by a trend log in a graphical chart in the operator interface.
 - 4) Trend log viewing capabilities shall include the ability to show a minimum of 5 points on a chart.
 - 5) Each data point trend line shall be displayed as a unique color.
 - 6) The operator shall be able to specify the duration of historical data to view by scrolling and zooming.
 - 7) The system shall provide a graphical trace display of the associated time stamp and value for any selected point along the x-axis.
 - c. Export Trend Logs.
 - 1) The operator interface shall allow a user to export trend log data in CSV or PDF format for use by other industry standard word processing and spreadsheet packages.
 5. Alarm/Event Notification
 - a. An operator shall be notified of new alarms/events as they occur while navigating through any part of the system via an alarm icon.
 - b. Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any operator interface.
 - 1) The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in a minimum of 4 categories based on severity.
 - 2) Alarm/event messages shall use full language, easily recognized descriptors.
 - 3) Alarm/event messages shall be able to be routed to multiple e-mail recipients.
 - 4) An operator with the proper security level may acknowledge and clear alarms/events.
 - 5) All alarms/events that have not been cleared by the operator shall be stored by the central server in an alarm log database.
 - 6) Store alarm data in a standard format accessible to user-specified peer database/server.
 - 7) The alarm/event log shall include a comment field for each alarm/event that allows a user to add specific comments associated with any alarm.
 - 8) Provide a printer-friendly format for printing alarm logs.
 - 9) Ability to mass delete alarms based on filter criteria such as: alarm priority, date and time, alarm status, alarm source, and alarm type.
 - c. Alarm Processing.
 - 1) The operator shall be able to configure any object in the system to generate an alarm when transitioning in and out of a normal state.
 6. Reports and Logs.

- a. The operator interface shall provide a reporting package that allows the operator to select reports.
 - b. The operator interface shall provide the ability to schedule reports to run at specified intervals of time.
 - c. The operator interface shall allow a user to export reports and logs from the building controller in a format that is readily accessible by other standard software applications including spreadsheets and word processing. Acceptable formats include:
 - 1) CSV, HTML, XML, PDF
 - d. Reports and logs shall be readily printed to the system printer.
 - e. Provide a means to list and access the last 10 reports viewed by the user.
 - f. The following standard reports shall be available without requiring a user to manually configure the report:
 - 1) All Points in Alarm Report: Provide an on demand report showing all current alarms.
 - 2) All Points in Override Report: Provide an on demand report showing all overrides in effect.
 - 3) Commissioning Report: Provide a one-time report that lists all equipment with the unit configuration and present operation.
 - 4) Points report: Provide a report that lists the current value of all points
7. VAV Air System. An operator shall be able to view and control (where applicable) the following parameters via the operator interface:
- a. System Mode
 - b. System Occupancy
 - c. Ventilation (Outdoor air flow) setpoint
 - d. Ventilation (Outdoor air flow) status
 - e. Air Handler Static pressure setpoint
 - f. Air Handler Static pressure status
 - g. Air Handler occupancy status
 - h. Air Handler Supply air cooling and heating set points
 - i. Air Handler minimum, maximum and nominal static pressure setpoints
 - j. VAV box minimum and maximum flow
 - k. VAV box drive open and close overrides
 - l. VAV box occupancy status
 - m. VAV box Airflow to space
 - n. Average space temperature
 - o. Minimum space temperature
 - p. Maximum space temperature
8. Custom Application Programming. Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded.
9. Custom Graphic Editor. Provide the tools to create, modify, and debug custom graphics. The operator shall be able to create, edit, and download custom graphics at the same time that all other system applications are operating. The system shall be fully operable while custom graphics are edited, compiled, and downloaded.

2.09 APPLICATION AND CONTROL SOFTWARE

- A. The central server shall provide the following applications within the system.
 1. Trend Log Application
 - a. The system shall automatically harvest trend logs for defined key measurements for each controlled HVAC device and HVAC application.

- b. The automatic trend logs shall monitor these parameters for a minimum of 30 days at 15 minute intervals. The automatic trend logs shall be user adjustable.
- 2. Site Management
 - a. The system must allow for grouping of the many sites in an enterprise in a logical manner.
 - b. The system shall provide a search function to allow users to search for sites or groups of sites by name or partial names.
 - c. The system must provide the necessary means to add, remove, and manage site
- 3. Automatic System Database Save and Restore.
 - a. The central server shall store on the hard disk backup tables of data including trends, alarms, custom settings and user profiles.
 - b. The data shall be backed up once a day.
 - c. This database shall be updated whenever a change is made in the system.
 - d. The storage of this data shall be automatic and not require operator intervention.
 - e. This capability is completed through SQL scheduled automated tasks for backup and only available in full SQL, and not SQL Express.
- 4. Manual Database Save and Restore. A system operator with the proper password clearance shall be able to archive the database manually at any time.
- 5. System Configuration. The central server shall serve web pages as the interface for configuring the operator-level functions of the system. A user with proper security shall be able to configure the system to allow for future changes or additions.

2.10 SYSTEM CONTROLLERS

- A. Central Server Components
 - 1. The central server shall consist of the following (minimum):
 - 2. System shall utilize a server class PC, tower or rack mounted
 - 3. Two Xeon 2.8GHz, 1MB L3 cache processors
 - 4. 2GB, DDR266 SDRAM memory
 - 5. DVD+R/W or CD ROM
 - 6. Microsoft Windows Server 2003 (IIS 6.0) Or Server 2008, IIS V7 +
 - 7. Microsoft SQL Server 2005
 - 8. .NET Framework 1.1 BJE: .NET 3.5
 - 9. Furnish all required serial, parallel, and network communication ports, and all cables for proper system operation. The server shall include a minimum 17", color monitor with 1024 x 768 screen resolution.

2.11 FIELD DEVICES:

- A. All devices and equipment shall be approved for installation by the Mechanical Consulting Engineer.
- B. Temperature Sensors - with accuracy of + .5 F @ 77 degrees F.
 - 1. Digital room sensors shall have LCD display, day/night override button, and set point slide adjustment override options. The set point slide adjustment can be software limited by the automation system to limit the amount of room adjustment. Mount at 54 "aff as indicated.
- C. Humidity Sensors - with accuracy of + 2% RH @ 77 deg. F. including hysteresis, linearity, and repeatability.
- D. Pressure Sensors - Setra.
- E. Dampers sized for specific application.

- F. Damper Operators, sized for specific application.
- G. Automatic Control Valves, sized for specific application.
- H. Air Volume Measurement (accurate down to 100 ft./min.).
- I. Smoke Detectors - BRK 120 V ionization duct type.
- J. Firestats - for applications less than 2000 CFM.
- K. Low Temperature Detection Stat.
- L. Electric Thermostats.
- M. Differential Pressure Switch.

2.13 DAMPER OPERATORS:

- A. All damper operators shall be electric and shall be two-position or proportional as indicated. They shall be furnished in sufficient numbers and with sufficient power to insure satisfactory operation of the damper to provide tight close off. They shall be spring return type to return the damper to the normal positions indicated. Mark full open and full closed positions of all dampers. Marks shall be made with Bakelite nameplates, attached to ductwork.

PART THREE - EXECUTION:

3.01 PROJECT MANAGEMENT:

- A. Provide a designated project manager who will be responsible for the following:
 - Construct and maintain project schedule
 - On-site coordination with all applicable trades and subcontractors
 - Authorized to accept and execute orders or instructions from Owner/Architect
 - Attend project meetings as necessary to avoid conflicts and delays
 - Make necessary field decisions relating to this scope of work
 - Coordination/single point of contact.
- B. The Contractor shall collaborate with the Owner directly to determine the Owner's preference for naming conventions, etc. before entering the data in to the system.

3.02 START-UP AND COMMISSIONING:

- A. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting and final field tests shall be completed by the manufacturer. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power.
- B. 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.

3.03 TRAINING:

- A. The manufacturer shall provide factory trained instructor to give full instruction to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The manufacturer shall provide all students with a student binder containing product specific training modules for the system installed. All training shall be held during normal working hours of 8:00 A.M. to 4:30 P.M. weekdays.
- B. Provide 40 hours of training for Owner's designated operating personnel. Training shall include:
 - Explanation of drawings, operations and maintenance manuals
 - Walk-through of the job to locate control components
 - Operator workstation and peripherals
 - DDC Controller and ASC operation/function
 - Operator control functions including graphic generation and field panel programming
 - Operation of portable operator's terminal
 - Explanation of adjustment, calibration and replacement procedures
 - Student binder with training modules.
- C. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Manufacturer. If such training is required by the Owner, it will be contracted at a later date.

3.04 SEQUENCE OF OPERATION:

- A. VAV Packaged Rooftop Units:
 - 1. Each air handling unit shall be optimally started and stopped by the BAS according to its occupied and unoccupied schedule. The RTU smoke dampers shall open, and then the supply fan shall ramp up to its cooling airflow (CFM).
 - 2. During unoccupied hours and morning start up operation, the motorized outside air damper shall remain closed. When in occupied operation, the outside air damper shall modulate to maintain its minimum required outside airflow (CFM) as measured by a factory mounted duct airflow station.
 - 3. A duct static pressure transmitter shall allow the BAS to operate the supply fan variable speed drive in order to maintain the duct static pressure set point. A duct static pressure high limit switch shall shut down the air handling unit and alarm the BAS if its set point is exceeded.
 - 4. The RTU supply air temperature shall be controlled to maintain its set point by cycling the compressors.
 - 5. AHU duct smoke detectors shall be provided and installed under this section of the Specifications. Wiring of the RTU duct smoke detectors to the fire alarm system shall be accomplished by Division 26. Interlock wiring for shutdown of the air handling units from the AHU duct smoke detectors shall be accomplished under this section of the Specifications. The RTU duct smoke detectors will alarm the BAS in the event that products of combustion are detected.
 - 6. The building automation system (BAS) shall continuously monitor the damper position

of all VAV terminal units. The discharge duct static pressure shall be sensed directly at the discharge of each Air handling unit. The sensor must be mounted in a non-turbulent location. The BAS shall also read the status on the supply air sensor and display the pressure reading on the status screen. The building automation system shall monitor the damper position of all VAV terminal units and determine each VAV AHU's critical zone VAV terminal (CZ), which is the VAV terminal unit that is the widest open. When any VAV damper is more than 85% (adj.) open, the supply fan discharge duct static pressure setpoint shall be reset upward by 0.1 in W.C. (adj.), at a frequency of 15 minutes (adj.), until no damper is more than 85% open or the static pressure setpoint has reset upward to the system maximum duct static pressure setpoint or the AHU variable-frequency drive is at the maximum speed setting.

When all VAV dampers are less than 65% (adj.) open, the supply fan discharge duct static pressure setpoint shall be reset downward by 0.1 in W.C. (adj.), at a frequency of 15 minutes (adj.), until at least one damper is more than 65% open or the static pressure setpoint has reset downward to the system minimum duct static pressure setpoint or the AHU variable-frequency drive is at the minimum speed setting. The BAS shall have the capability to allow the operator to exclude "problem" zones that should not be considered when determining the optimized setpoint. The BAS shall have the ability to identify, and display to the user, the VAV box that serves the Critical Zone (that is, the zone with the most wide-open VAV damper). This information shall update dynamically as the location of the Critical Zone changes based on building load, and duct static pressure setpoint optimization control.

The control bands, setpoint increment values, setpoint decrement values and adjustment frequencies shall be adjusted to maintain maximum static pressure optimization with stable system control and maximum comfort control.

B. Constant Volume Packaged Rooftop Units

1. The Building Automation System (BAS) will send the controller Occupied, Unoccupied, Optimal Start, Night Heat / Cool, and Timed Override commands. If communication is lost with the BAS, the controller will operate using its local schedule and setpoints.
2. In the unoccupied mode the rooftop unit (RTU) will cycle as required to maintain the adjustable (adj) unoccupied space heating and cooling setpoints. When the associated zone temperature rises above or falls below the unoccupied setpoint, the RTU will be enabled. Once enabled, the supply fan, heat, and DX cooling will cycle as required to maintain the unoccupied zone temperature setpoint. The outside air damper will remain closed, and the return air damper will remain open during unoccupied mode.
3. On a transition from the unoccupied mode to occupied mode, if the zone temperature is 3°F below the occupied setpoint a morning warm-up routine mode will be activated. When morning warm-up is initiated the RTU will enable the unit's heat and supply fan. The outside air damper will remain closed. When the zone temperature reaches setpoint (adj), the RTU will transition to the occupied mode.
4. On a transition from the unoccupied mode to occupied mode, if the zone temperature is 3°F above the occupied setpoint a morning cool-down mode will be activated. When morning cool-down is initiated the RTU will enable the fan and DX cooling or economizer. The outside air damper will remain closed. When the zone temperature reaches setpoint (adj), the RTU will transition to the occupied mode.
5. The RTU will enable cooling or heating to maintain zone temperature setpoint (adj). The outdoor air damper will open to the minimum setpoint. (RTU 2 and 3 only) The heat recovery wheel, energy recovery supply fan and exhaust fan system will be interlocked to operate with the RTU 2 and RTU 3.

6. The controller uses zone temperature and zone temperature setpoint to determine when to initiate requests for cooling. When the zone temperature rises above the setpoint, the controller will enable stage-1 of cooling. The controller will call for the supply fan to turn on. The first compressor will energize after its minimum 3-minute off time has expired. If additional cooling capacity is required the second stage of cooling will be enabled. Once the zone temperature falls below the setpoint the compressors and fan will be deactivated. The supply fan will remain on for a period of 60 seconds after the compressor output is de-energized for free cooling.
7. The controller uses zone temperature and zone temperature setpoint to determine when to initiate requests for heat. When the zone temperature drops below the setpoint, the controller will enable stage-1 of heat. The controller will call for the supply fan to turn on. The first stage of heat will energize. If additional heating capacity is required the second stage of heat will be enabled. Once the zone temperature rises above the setpoint the heating stages and the fan will be disabled. On gas heat units the supply fan will remain on for a period of 90 seconds after heat is deactivated for free heating and heat exchanger cool down.
8. The supply fan will be enabled while in the occupied mode and cycled on during the unoccupied mode. A differential pressure switch will monitor the differential pressure across the fan. If the switch does not open within 40 seconds after a request for fan operation a fan failure alarm will be annunciated, the unit will stop, requiring a manual reset.
9. When the demand control ventilation (DCV) threshold is reached, the economizer will start to modulate open to bring in more fresh air to reduce the CO2 level. The damper will modulate open in small increments until the CO2 level is satisfied or the damper reaches the full open position. Once the threshold is satisfied, the damper will return to normal economizer operation. If the mixed air temperature drops to 40° F, the CO2 sensor input is overridden and closes the damper to minimum position to prevent hot water coils from freezing, or if gas heating, to prevent condensation in the heat exchanger. When the mixed air temperature rises to 43°F, CO2 or economizer operation is once again restored.
10. Area control monitors the status of the “on” and “cancel” buttons of the zone temperature sensors associated with the area. When a timed override request from a Trane zone temperature sensor, is sensed, the area will change from its current state to occupied.
11. A differential pressure switch will monitor the differential pressure across the filter when the fan is running. If the switch closes for 2 minutes after a request for fan operation a dirty filter alarm will be annunciated.

C. VAV Boxes with Electric Heat:

1. During the occupied mode, the Terminal Equipment Controller (TEC) modulates the primary supply air damper within user defined separate heating and cooling maximum and minimum air volume settings by sensing the inlet air velocity (CFM).
2. On a rise in temperature above the room cooling set point, the Terminal Equipment Controller (TEC) shall modulate open the duct supply air damper to maintain room temperature.
3. Similarly, on a fall in temperature below the room heating set point, the Terminal Equipment Controller (TEC) shall modulate the supply duct damper to its minimum position, and then the electric heater elements will stage to maintain the room

temperature.

4. When commanded to change over to the Unoccupied Mode, the Terminal Controller shall raise cooling set point and decrease the heating set point (as appropriate) to operator-determined values.
5. During the Unoccupied Mode, the Terminal Controller shall be reset to the Occupied Mode for an operator determined time period. This reset shall be activated by a signal from a local override switch on the room temperature sensor. At the end of the operator determined time period, the Terminal Controller shall return to the Unoccupied Mode.

D. Exhaust Fans:

1. The exhaust fans shall be controlled as indicated on the equipment schedule by thermostat, wall switch, or the BAS.

E. Single Zone Variable Volume Rooftop Packaged Unit

1. Unoccupied Mode - When the BAS initiates the unoccupied mode, the Air Handling Unit shall assume the unoccupied heating and cooling setpoints. If the unoccupied setpoints are exceeded, the unit shall heat or cool until the zone temperature is within the unoccupied setpoints.
2. Night Setback Temperature Control - During unoccupied hours, the Air Handling Unit shall be controlled by the BAS to maintain user-defined unoccupied heating and cooling setpoints. The outdoor air damper shall remain closed for night setback operation (unless economizing for zone cooling). The fan shall operate in the automatic control mode.
3. Occupied Operation - When the Air Handling Unit is controlled to the occupied mode, all Air Handling Unit functions shall be enabled units and shall operate in supply air temperature control mode. The Air Handling Unit shall default to this mode in the event that communications with the BAS are lost.
4. Economizer Control - The BAS shall override the economizer controller on the Air Handling Unit to provide free cooling. If poor outdoor air conditions exist, the BAS shall lockout all economizers.
5. Shutdown - The BAS Priority Control program shall be able to put the zone in either the Shutdown or Occupied mode. All units which are members of that zone shall be immediately put in the Shutdown or Occupied mode. In the Shutdown mode, the unit shall turn off as rapidly as possible with all cooling and heating disabled, and the outdoor air damper shall be closed.
6. The temperature in the zone shall be maintained by varying the quantity of air delivered to the zone, rather than by varying the discharge air temperature.
7. The air handling unit discharge air temperature setpoint shall be 55°F (adjustable). The air handling unit shall modulate its cooling capacity to maintain a constant discharge air temperature.
8. The zone temperature shall be used as an input to the DDC controller on the air handler to be used to determine the volume of air, in CFM, that is to be delivered to the zone.
 - a. On a decrease in cooling load in the zone, the air handling unit shall reduce the

volume of air being delivered to the zone to satisfy the zone temperature setpoint. If the space temperature continues to fall below setpoint and the air volume is at minimum the discharge air temperature will be reset upward. If the space temperature continues to drop below the heating setpoint the fan will be ramped to half speed and the modulating gas heat will be staged on to satisfy the heating setpoint.

- b. On an increase in cooling load in the zone, the air handling unit shall increase the volume of air being delivered to the zone to satisfy the zone temperature setpoint.
9. CO2 (Carbon Dioxide) Control- Monitor space occupancy levels within the area served by measuring the parts per million of CO2 (Carbon Dioxide) in the return air. As the CO2 levels increase, the outside air damper modulates to meet the CO2 space ventilation requirements.
10. Diagnostic/Protection - The BAS system shall be able to alarm from all sensed points from the Air Handling and diagnostic alarms sensed by the unit controller. Alarm limits shall be designated for all sensed points.

INPUT/OUTPUT POINTS LIST SUMMARY

VAV PACKAGED ROOFTOP UNITS (typical for each)

Point Description:	AI	AO	DI	DO
Supply Fan Status			X	
Supply Fan Start/Stop				X
Supply Fan VFD Control		X		
Supply Air Duct Temperature	X			
Supply Air Duct Static	X			
Duct Smoke Detector(s)			X	
Mixed Air Duct Temperature	X			
Filter Alarm				X
Compressor control as a percentage	X			
OA/RA Air Damper Control		X		
Outside Air Flow Station CFM	X			

CONSTANT VOLUME ROOFTOP PACKAGED UNITS

Point Description:	AI	AO	DI	DO
Space temperature	X			
Space Temperature setpoint	X			

Occupancy Override					X
Outdoor Temperature	X				
Active Temperature Setpoint	X				
Discharge Air Temperature	X				
Outside Air Damper Position			X		
Dirty Filter					X
Supply Fan Status					X
Supply Fan Start / Stop					X

High Pressure Compressor Protection					X
Low Pressure Compressor Protection					X
Compressor Status				X	
Condenser Fan Status				X	
Percent Cooling Output		X			
Percent Heating Output		X			

TYPICAL FOR ALL VAV BOXES

Point Description:	AI	AO	DI	DO
CFM	X			
Room Temperature	X			
Room Set point Adjustment		X		
Override Button			X	
Damper Control		X		
Gas Heat Control		X		

SINGLE ZONE VAV PACKAGED ROOFTOP UNITS (typical for each)

Point Description:	AI	AO	DI	DO
Supply Fan Status			X	
Supply Fan Start/Stop				X
Supply Fan VFD Control		X		
Space Temperature	X			

Space Temperature setpoint	X			
Supply Air Duct Static	X			
Duct Smoke Detector(s)			X	
Mixed Air Duct Temperature	X			
Filter Alarm				X
Percentage of Cooling	X			
OA/RA Air Damper Control		X		
Outside Air Flow Station CFM		X		
High Pressure Compressor Protection				X
Low Pressure Compressor Protection				X
Compressor Status			X	
Condenser Fan Status			X	
Percent Cooling Output		X		
Percent Heating Output		X		

INPUT/OUTPUT POINTS LIST SUMMARY

MISCELLANEOUS

Point Description:	AI	AO	DI	DO
Outside Air Temperature	X			
Outside Air R.H.	X			
Fire Alarm Panel Status (allow one point for each floor)			X	
Building KW Pulsemeter (provided by BAS Contractor)			X	

END OF SECTION 23 90 40