

Physical Plant  
Department of Operations

MEMORANDUM

TO: James Campoli  
FROM: Christopher Camastra  
SUBJECT: METASYS / New Equipment Connectivity Standards  
DATE: November 24, 2003

FMS Description

The FMS shall tie – in completely and seamlessly to the existing Johnson Controls Metasys system. All points shall be mapped back and viewable from the existing Johnson Controls Metasys workstation existing at 65 Bergen Street, Newark, NJ. New data must have read-write capability at existing workstation. Emulation programs are not acceptable.

The FMS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned FMS.

Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for the Project.

Manage and coordinate the FMS work in a timely manner. Coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.

Information management including monitoring, transmission, archiving, retrieval, and reporting functions.

Diagnostic monitoring and reporting of FMS functions.

**Comment [JC11]:** Edit or delete according to specific project requirements- also see 2.5 - A.2

## Quality Assurance

### General

The FMS Contractor shall be a recognized national manufacturer, installer and service provider of FMS. Distributors, manufacturer's representatives and wholesalers will not be acceptable.

The FMS Contractor shall have a branch facility within a 30-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis. This branch facility shall provide the work for this project. This support facility shall have a spare parts and all necessary test and diagnostic equipment required to install, commission and service the specified FMS.

As evidence and assurance of the contractor's ability to support the Owner's system with service and parts, the contractor must have been in the FMS business for at least the last twenty (10) years and have successfully completed total projects of at least 10 times the value of this contract in each of the preceding five years.

The Facility Management System architecture shall consist of the products of a manufacturer regularly engaged in the production of Facility Management Systems, and shall be the manufacturer's latest standard of design at the time of bid.

Coordinate as necessary with other trades.

Be responsible for the work and actions of the FMS workforce on site.

### References

All work shall conform to the following Codes and Standards, as applicable:

**Comment [JC12]:** Edit this list to reflect those that apply for the specific project.

1. National Fire Protection Association (NFPA) Standards.
2. National Electric Code (NEC) and applicable local Electric Code.
3. Underwriters Laboratories (UL) listing and labels.
4. UL 864 UUKL Smoke Control
5. UL 268 Smoke Detectors.
6. UL 916 Energy Management
7. NFPA 70 - National Electrical Code.
8. NFPA 90A - Standard For The Installation Of Air Conditioning And Ventilating Systems.
9. NFPA 92A and 92B Smoke Purge/Control Equipment.
10. Factory Mutual (FM).
11. American National Standards Institute (ANSI).
12. National Electric Manufacturer's Association (NEMA).

13. American Society of Mechanical Engineers (ASME).
14. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) [user note: add ASHRAE 62 IAQ as applicable].
15. Air Movement and Control Association (AMCA).
16. Institute of Electrical and Electronic Engineers (IEEE).
17. American Standard Code for Information Interchange (ASCII).
18. Electronics Industries Association (EIA).
19. Occupational Safety and Health Administration (OSHA).
20. American Society for Testing and Materials (ASTM).
21. Federal Communications Commission (FCC) including Part 15, Radio Frequency Devices.
22. Americans Disability Act (ADA)

**Comment [JC13]:** Edit or delete according to specific project requirements- also see 2.5 - A.2

In the case of conflicts or discrepancies, the more stringent regulation shall apply.

All work shall meet the approval of the Authorities Having Jurisdiction at the project site.

### Work By Others

The demarcation of work and responsibilities between the FMS Contractor and other related trades shall be as outlined in the FMS RESPONSIBILITY MATRIX herein

**Comment [JC14]:** The FMS Responsibility Matrix may be deleted if the consultant doesn't want it, or if the salesperson wants to obscure the scope of work for competitive advantage. This matrix requires extensive review and modifications for the specific project.

FMS RESPONSIBILITY MATRIX				
WORK	FURNISH	INSTALL	Low Volt. WIRING/TUBE	LINE POWER
FMS low voltage and communication wiring	FMS	FMS	FMS	N/A
VAV box nodes	FMS	15	FMS	16
FMS conduits and raceway	FMS	FMS	FMS	FMS
Automatic dampers	FMS	15	N/A	N/A
Manual valves	15	15	N/A	N/A
Automatic valves	FMS	15	FMS	N/A
VAV boxes	15	15	N/A	N/A
Pipe insertion devices and taps including thermowells, flow and pressure stations.	FMS	15	FMS	FMS
FMS Current Switches.	FMS	FMS	FMS	N/A
FMS Control Relays	FMS	FMS	FMS	N/A
Power distribution system monitoring interfaces	16	16	FMS	16
Control air compressors	FMS	FMS	N/A	16
Concrete and/or inertia equipment pads	15	15	N/A	N/A

**Comment [JC15]:** Edit or delete according to specific project requirements

and seismic bracing				
FMS interface with Chiller controls	FMS	FMS	FMS	FMS
Chiller controls interface with FMS	15	15	FMS	16
All FMS Nodes, equipment, housings, enclosures and panels.	FMS	FMS	FMS	FMS
Smoke Detectors	16	16	16	16
Fire/Smoke Dampers	15	15	FMS	16
Fire Dampers	15	15	N/A	N/A
Chiller Flow Switches	15	15	FMS	N/A
Boiler wiring	15	15	15	15
Water treatment system	15	15	15	16
VFDs	15	16	FMS	16
Refrigerant monitors	15	FMS	FMS	16
Computer Room A/C Unit field-mounted controls	15	15	FMS	16
Fire Alarm shutdown relay interlock wiring	16	16	16	16
Fire Alarm smoke control relay interlock wiring	16	16	FMS	16
Fireman's Smoke Control Override Panel	16	16	16	16
Fan Coil Unit controls	FMS	FMS	FMS	16
Unit Heater controls	FMS	FMS	FMS	16
Packaged RTU space mounted controls	15	FMS	FMS	16
Packaged RTU factory-mounted controls	15	15	FMS	16
Packaged RTU field-mounted controls	FMS	FMS	FMS	16
Heat Pump Controls	FMS	HP MFG	FMS	16
Cooling Tower Vibration Switches	15	15	16	16
Cooling Tower Level Control Devices	15	15	16	16
Cooling Tower makeup water control devices	15	15	16	16
Pool Dehumidification Unit Controls	15	15	FMS	16
Starters, HOA switches	16	16	N/A	16
Control damper actuators	FMS	FMS	FMS	16

**Comment [JC16]:** Adjust times and quantities as required for the project.

## Submittals

### Shop Drawings, Product Data, and Samples

Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved by the Architect and Engineer for Contract compliance.

Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the FMS Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Owner.

Prepare an index of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.

The FMS Contractor shall correct any errors or omissions noted in the first review.

At a minimum, submit the following:

- FMS network architecture diagrams including all nodes and interconnections.

- Schematics, sequences and flow diagrams.

- Points schedule for each point in the FMS, including: Tag, Point Type, System Name, Object Name, Expanded ID, Display Units, Node Type, Address, Cable Destination, Module Type, Terminal ID, Panel, Slot Number, Reference Drawing, and Cable Number.

- Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Blade Type, Bearing Type, Seals, Duct Size, Damper Size, Mounting, and Actuator Type.

- Control Valve Schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Calculated CV, Design Pressure, Actual Pressure, and Actuator Type.

- Room Schedule including a separate line for each VAV box and/or terminal unit indicating location and address

- Details of all FMS interfaces and connections to the work of other trades.

- Product data sheets for all products including software.

## Record Documentation

### Operation and Maintenance Manuals

Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Physical Plant upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the FMS provided:

- Table of contents.

- As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.

- Manufacturers product data sheets for all products including software.

- System Operator's manuals.

- Archive copy of all site-specific databases and sequences.

- FMS network diagrams.

- Interfaces to all third-party products and work by other trades.

The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view

and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

## Warranty

### Standard Material and Labor Warranty:

Provide a one-year labor maintenance, labor warranty repairs and material warranty on all FMS connected equipment. Response time shall be within 4 hours of notification by the Owner. If within twelve (12) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the FMS connected equipment Contractor at the cost of the FMS connected equipment Contractor.

Maintain an adequate supply of materials within 100 miles of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during FMS connected equipment Contractor's normal business hours.

## FMS Interface Architecture

### General

The FMS interface shall consist of a number of Nodes and associated equipment connected by industry standard network practices. All communication between Nodes shall be by digital means only.

The FMS network shall at minimum comprise of the following:

- Operator Workstations

- Network processing, data storage and communication equipment including file servers.

- Routers, bridges, switches, hubs, modems and like communications equipment.

- Active processing Nodes including field panels.

- Intelligent and addressable elements and end devices.

- Third-party equipment interfaces.

- Other components required for a complete and working FMS.

The FMS shall support auto-dial/auto-answer communications to allow FMS Nodes to communicate with other remote FMS Nodes via standard telephone lines.

The PC Workstations, File servers and principal network equipment shall be standard products of recognized major manufacturers available through normal PC vendor channels. "Clones" are not acceptable.

Provide licenses for all software residing in the FMS system and transfer these licenses to the Owner prior to completion.

### Network

The FMS shall incorporate a primary Tier 1 network. At the Contractor's option, the FMS may also incorporate integrated secondary Tier 2 and tertiary Tier 3 networks.

The FMS Network shall utilize an open architecture capable of all of the following:

Utilizing standard Ethernet communications and operate at a minimum speed of 10Mb/sec

Connecting via BACnet.

The FMS network shall support both copper and optical fiber communication media.

### Third-Party Interfaces

FMS Contractor shall integrate real-time data from systems supplied by other trades as required.

The FMS system shall include necessary FMS hardware equipment and software to allow data communications between the FMS system and systems supplied by other trades.

The trade contractor supplying other systems will provide their necessary hardware and software and will cooperate fully with the FMS contractor in a timely manner at their cost to ensure complete data integration.

### Power Fail / Auto Restart

Provide for the automatic orderly and predefined startup of parts or all of the FMS following total loss of power to those parts or all of the FMS. Archive and annunciate time and details of restoration.

Provide for the orderly and predefined scheduling of controlled return to normal, automatically time scheduled, operation of controlled equipment as a result of the auto restart processes.

Maintain the FMS real-time clock operation during periods of power outage for a minimum of 72 hours.

### Downloading And Uploading

Provide the capability to generate FMS software-based sequences, database items and associated operational definition information and user-required revisions to same on designated OWS, and the means to download same to the associated Application Node.

Provide the capability to upload FMS operating software information, database items, sequences and alarms to the designated OWS with automatic archiving of same on the OWS.

The functions of this Part shall be governed by the codes, approvals and regulations applying to each individual FMS application.

### Operator Interface (utilize existing)

#### General

Additions to the FMS Operator Interface shall be user friendly, readily understood and shall make maximum use of colors, graphics, icons, embedded images,

**Comment [JC17]:** Salesperson should make sure that mechanical/electrical sections contain paragraph Manf. must be responsible for providing the necessary hardware and software to interface with the FMS. Example: make sure that a DDC panel is specified in the chiller spec.

animation, and text based information to enhance and simplify the use and understanding of the FMS by authorized users at the OWS.

User access to the FMS shall be protected by a flexible and Owner redefinable software-based password access protection. Password protection shall be multi-level and partitionable to accommodate the varied access requirements of the different user groups. Provide the means to define unique access privileges for each individual authorized user. Provide the means to on-line manage password access control under the control of a Master Password.

Any additional Interface points shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:

- User access for selective information retrieval and control command execution

- Monitoring and reporting

- Alarm and non-normal condition annunciation

- Selective operator override and other control actions

- Information archiving, manipulation, formatting, display and reporting

- FMS internal performance supervision and diagnostics

- On-line access to user HELP menus

- Means for the controlled re-programming, re-configuration of FMS operation and for the manipulation of FMS database information in compliance with the prevailing codes, approvals and regulations for individual FMS applications.

Provide FMS reports and displays making maximized use of simple English language descriptions and readily understood acronyms, abbreviations and the like to assist user understanding and interpretation. All text naming conventions shall be consistent in their use and application throughout the FMS.

All PC-based configurations shall operate on Microsoft® Windows

Each fixed and/or portable OWS shall be on-line configurable for specific applications, functions and groups of FMS points.

#### Alarms

Designated OWS shall annunciate alarms generated by the FMS. The alarm management portion of the OWS software shall, at the minimum, provide the following functions

- Log date and time of alarm occurrence.

- Generate a "Pop-Up" window, with audible alarm, informing a user that an alarm has been received.

- Allow a user, with the appropriate security level, to acknowledge, or disable an alarm.

- Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.

The FMS shall announce diagnostic alarms indicating system failures and non-normal operating conditions

## Reports

Reports shall be generated and directed to one or more of the following: OWS display, printer, or archive at the user's option. As a minimum, the system shall provide the following reports:

All points in the FMS.

All points in each FMS application.

All points in a specific AN.

All points in a user-defined group of points.

All points currently in alarm in an FMS application.

All points locked out in an FMS application.

All FMS schedules.

All user defined and adjustable variables, schedules, interlocks and the like.

FMS diagnostic and system status reports.

Provide all applicable standard reports of the FMS manufacturer.

Provide for the generation by the user of custom reports.

**Comment [JC18]:** Define the requirements under Part 3. Use appropriate VMA reports, etc.

## Schedules

Provide a spreadsheet-type schedule input form for automatic FMS time-of-day scheduling and override scheduling of FMS operations shall be provided. At a minimum, the following spreadsheet types shall be accommodated:

Weekly schedules.

Temporary override schedules.

Special "Only Active If Today Is A Holiday" schedules.

Monthly schedules.

Schedules shall be provided for each system or sub-system in the FMS. Each schedule shall include all commandable points residing within the system. Each point may have a unique schedule of operation relative to the system use schedule, allowing for sequential starting and control of equipment within the system. Scheduling and rescheduling of points shall be accomplished easily via the system schedule spreadsheets.

Monthly calendars for a 12-month period shall be provided that allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

## Historical trending and data collection

Trend and store point history data for all FMS points and values as indicated on point list in Part 3 of these specifications. The system shall provide and support user-selectable trends and histories.

The trend data shall be stored in a manner that allows custom queries and reports using industry-standard software tools.

At a minimum, provide the capability to perform statistical functions on the historical database:

Average.  
Arithmetic mean.  
Maximum/minimum values.  
Range – difference between minimum and maximum values.  
Standard deviation.  
Sum of all values.  
Variance.

**Comment [JC19]:** Application Nodes covers the various field panels – HVAC ASCs, Fire, Security, etc.

## Application Nodes

### General

The Application Nodes (AN) shall include all monitoring, control and information Nodes including field panels.

AN shall be programmable and governed by the requirements of their applicable codes, approvals and regulations.

The AN shall be designed, packaged, installed, programmed and commissioned in consideration of their specific service and prevailing operating conditions. They shall be proven standard product of their original manufacturer and not a custom product for this Project.

A failure at an AN shall not cause failures or non-normal operation at any other system AN other than the possible loss of active real-time information from the failed AN.

Ancillary AN equipment, including interfaces and power supplies, shall not be operated at more than 80% of their rated service capacity.

AN shall comply with FCC Part 15 subpart J class A emission requirements.

### HVAC Node

HVAC Node shall provide both standalone and networked direct digital control of HVAC systems.

A dedicated HVAC Node shall be configured and provided for each primary HVAC system (air handler, chiller, boiler) and each terminal HVAC system (VAV Box, Unit Ventilator, Classroom Single Zone Unit, Unit Heater, Fan Coil Unit, Cabinet Heater, Heat Pump, Fan Powered Box, CV Box).

Each HVAC Node shall be able to retain program, control algorithms, and setpoint information for at least 72 hours in the event of a power failure, and shall return to normal operation upon restoration of power.

Each HVAC Node shall report its communication status to the FMS. The FMS shall provide a system advisory upon communication failure and restoration.

For each primary HVAC system, provide means of indication of system performance and setpoints at, or adjacent to the HVAC Node.

For each primary HVAC system, provide a means to adjust setpoints and start/stop equipment at, or adjacent to the HVAC Node.

Provide a means to prevent unauthorized personnel from accessing setpoint adjustments and equipment control functions.

The HVAC Node shall provide the ability to modify configuration data, both locally at the Node and via the FMS communications network.

## Application Software

### HVAC Application Software

**Event Messaging:** Provide for the automatic execution of user-defined messages on the occurrence of each predefined FMS real-time event including equipment/point status change, approaching limit or alarm, time of day and the like.

**Optimum Start/Stop:** Provide software to start equipment on a sliding schedule based upon indoor and outdoor conditions, to determine the minimum time of HVAC system operation needed to satisfy the space environmental requirements. The program shall also determine the earliest possible time to stop the mechanical systems. The optimum start/stop program shall operate in conjunction with, and be coordinated with, the scheduled start/stop and night setback programs.

**Auto Alarm Lockout:** Provide for scheduled and automatic lockout of alarm annunciation from equipment during non-normal operating conditions including shutdown, emergency power operation, fire alarm and the like.

**Demand Limiting:** Provide software to limit excess utility charges caused by uncontrolled demand. Provide the ability to prioritize the demand limiting actions based on FMS system parameters.

#### Event Initiated Programs:

**Comment [JCI10]:** Edit or delete according to specific project requirements

**System Restart:** Upon restoration of the AC power to an HVAC Node, automatically restart all equipment and restore all loads to the state as required by the FMS. Provide appropriate time delays to prevent demand surges or overload trips.

**Heavy Equipment Delays:** The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

**Runtime Totalization:** Automatically sample, calculate and store runtime hours for binary input and output points as listed in the point schedule of this specification.

**Analog/Pulse Totalization:** Sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

Provide all software specified. Implement application software as indicated in specifications.

## Network Controllers

### Network Controller

The Network Controller shall be a fully user-programmable, supervisory controller. The Network Controller shall monitor the network of distributed

application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Controllers.

First Tier Network – The Network Controller (NC) shall reside on the first tier network. Each NC shall support a sub-network of a minimum of 100 controllers on the second tier network.

Open Systems Port – Each controller shall have the ability to connect to third-party control systems by way of an Open Systems Port, as specified or as shown on the design drawings. All programming required to implement the OSP shall reside solely within the controller and the associated device.

Processor – Controllers shall be microprocessor-based with a minimum word size of 16 bits and a maximum program scan rate of 1 second. They shall be multi-tasking, multi-user, and real-time digital control processors. Controller size and capability shall be sufficient to fully meet the requirements of this Specification.

Memory – Each controller shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all second tier controllers.

Hardware Real Time Clock – The controller shall have an integrated, hardware-based, real-time clock.

Communications Ports – The NC shall provide at least two RS-232 serial data communication ports for operation of operator I/O devices, such as industry-standard printers, operator terminals, modems, and portable operator's terminals. Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or terminals.

Diagnostics – Controller shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The network controller shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.

Power Failure – In the event of the loss of normal power, there shall be an orderly shutdown of all controllers to prevent the loss of database or operating system software. Nonvolatile 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.

During a loss of normal power, the control sequences shall go to the normal system shutdown conditions.

Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

Should a controller memory be lost for any reason, the operator workstation shall automatically reload the program without any intervention by the system operators.

Certification – All controllers shall be listed by Underwriters Laboratories (UL).

## Application Specific Controllers

### Expanded Digital Controller (DX-9100)

Each DX-9100 shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each DX-9100 shall be a microprocessor-based, multi-tasking, real-time digital control processor.

DX-9100 controllers shall support, but not be limited to, the following configurations of systems to address current requirements described in the "Execution" portion of this Specification, and to address future expansion.

Air Handling Units.

Single boiler or chiller plants with pump logic.

Cooling towers.

Zone pressurization of labs.

Generic system interlocking through hardware.

Point types – Each DX-9100 shall support the following types of point inputs and outputs:

Analog inputs shall monitor the following analog signals:

4-20 mA Sensors

0-10 VDC Sensors

1000ohm RTDs

Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input "bouncing."

Counter inputs shall monitor dry contact pulses with an input resolution of one HZ minimum.

Analog outputs shall provide the following control outputs:

4.20 mA – Sink or Source

0-10 VDC

Binary outputs shall provide SPDT output contacts rated for 2 amps at 24 VAC. Surge and noise suppression shall be provided on all pilot relays. Inductive loads (i.e. solenoids) shall be controlled by pilot relays.

TriState outputs shall be paired binary outputs for use as Power Close/Power Open control output contacts rated for 2 amps at 24 VAC. Surge and noise suppression shall be provided on all pilot relays.

Pneumatic outputs shall provide a 3-15 PSI pneumatic output. Gradual override capability and output pressure gauge shall be provided.

### Manual Overrides

Manual override switches shall be provided for all binary outputs that do not have a MCC Hand/Off/Auto switch.

Switches shall be mounted within the system controller key-accessed enclosure, or the adjacent local control panel

Switches for analog outputs shall be rotary gradual position, providing the full analog signal range of the associated analog output, and shall be operable whether the panel processor is operational or not.

DX-9100 controllers shall have a built-in status, and adjust panel interface to allow for the local adjustment of all setpoints, temporary override of any input or output points, and status of any points in alarm.

Powerfail Protection – All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the DX-9100.

The capability to extend the input and output capacity of the DX-9100 via Point Expansion Modules shall be provided.

The Point Expansion Modules shall communicate to the DX-9100 controller over a local RS-485 expansion bus.

The Point Expansion Modules shall have available a range of configurations of 4, 8, 12, or 16 data points:

Analog Inputs – 0-10V, 4-20mA, 1000 ohm RTD

Analog Outputs – 0-10V, 4-20mA

Digital Inputs w/ digital counter

Digital Outputs – triacs or relay contacts

Expansion module data points shall be available for inclusion in all DX-9100 control strategies.

#### Unitary Controllers (UNT)

Each Unitary Controller shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each Unitary Controller shall be a microprocessor-based, multi-tasking, real-time digital control processor.

Unitary Controllers shall support, but not be limited to, the following types of systems to address specific applications described in the “Execution” portion of this Specification, and to address future expansion:

Unit Vents (ASHRAE Cycle, I, II, III, or W).

Packaged Rooftops.

Fan Coils (Two-Pipe, Four-Pipe).

Point types – Each Unitary Controller shall support the following types of point inputs and outputs:

Analog inputs shall monitor the following analog signals:

0-10 VDC Sensors

1000ohm RTDs

Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input “bouncing.”

Counter inputs shall monitor dry contact pulses with an input resolution of one HZ minimum.

Analog outputs shall provide the following control outputs:

0-10 VDC

Binary outputs shall provide SPDT output contacts rated for 2 amps at 24 VAC. Surge and noise suppression shall be provided on all pilot relays. Inductive loads (i.e. solenoids) shall be controlled by pilot relays.

TriState outputs shall be paired binary outputs for use as Power Close/Power Open control output contacts rated for 2 amps at 24 VAC. Surge and noise suppression shall be provided on all pilot relays.

Pneumatic outputs shall provide a 3-15 PSI pneumatic output. Gradual override capability and output pressure gauge shall be provided.

#### Manual Overrides

Manual override switches shall be provided for all binary outputs that do not have a MCC Hand/Off/Auto switch.

Switches shall be mounted within the system controller key-accessed enclosure, or the adjacent local control panel

Switches for analog outputs shall be rotary gradual position, providing the full analog signal range of the associated analog output, and shall be operable whether the panel processor is operational or not.

Unitary Controllers shall have a library of control routines and program logic to perform the sequence of operations specified in the "Execution" portion of this Specification.

Unitary Controllers shall directly support the temporary use of a portable service terminal that can be connected to the UNT via zone temperature or directly at the controller.

Powerfail Protection – All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the UNT.

#### Heat Pump Control

1. Furnish thermostat with LCD display and keypad for menu selection. The user shall be able to adjust heating or cooling setpoints, view the room or outside air temperatures, select continuous fan operation, and specify mode of operation (day/ night)

#### VAV Terminal Unit Controller (VMA)

The VMA shall provide both standalone and networked direct digital control of pressure-independent, variable air volume terminal units.

The VMA shall be a configurable digital controller with integral differential pressure transducer and damper actuator. All components shall be connected and mounted as a single assembly that can be removed as one piece.

The integral damper actuator shall be a fast response stepper motor capable of stroking 90 degrees in 30 seconds for quick damper positioning to speed commissioning and troubleshooting tasks.

The VMA shall be a configurable digital controller with an integral differential pressure transducer. It shall be compatible with 3 wire (incremental) and proportional damper actuators.

- The VMA shall determine airflow by dynamic pressure measurement using an integral dead-ended differential pressure transducer. The transducer shall be maintenance-free and shall not require air filters.
- Each VMA shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.
- The VMA shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.
- Each VMA shall continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. In addition, this tuning reduces commissioning costs, and eliminates the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.
- The VMA shall provide the ability to download and upload VMA configuration files, both locally and via the communications network. Controllers shall be able to be loaded individually or as a group using a zone schedule generated spreadsheet of controller parameters.
- VMA control setpoint changes initiated over the network shall be written to VMA non-volatile memory to prevent loss of setpoint changes and to provide consistent operation in the event of communication failure.
- The VMA firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.
- The VMA shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.
- The VMA shall interface with balancer tools that allow automatic recalculation of box flow pickup gain (“K” factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow setpoints.
- The VMA shall be capable of direct electronic connection to the Alnor DB150 Balometer balancing hood. Connection shall be through a port located on the room sensor, or directly at the controller. As an alternative, software balancing tools shall be provided that will run in a hand-held Palm Pilot type PC (such as the 3COM Palm Pilot or IBM Workpad). The balancing tools shall allow adjustment of airflow setpoints and parameters, and provide permanent upload of the values entered to the VMA. The Palm Pilot shall connect to the terminal unit through the room sensor port.
- The VMA performance shall be self-documenting via on-board diagnostics. These diagnostics shall consist of control loop performance measurements executing at each control loop’s sample interval, which may be used to continuously monitor and document system performance. The VMA shall calculate exponentially weighted moving averages (EWMA) for each of the following. These metrics shall be available to the end user for efficient management of the VAV terminals.
- Absolute temperature loop error.
  - Signed temperature loop error.

Absolute airflow loop error.  
Signed airflow loop error.  
Average damper actuator duty cycle.

The VMA shall detect system error conditions to assist in managing the VAV zones. The error conditions shall consist of:

Unreliable space temperature sensor.  
Unreliable differential pressure sensor.  
Starved box.  
Insufficient cooling.  
Insufficient heating.

The VMA shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality), and shall be capable of resetting the box minimum airflow based on the percent of outdoor air in the primary air stream.

The VMA shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.

The VMA shall be compatible with the U.S. EPA Energy Star Buildings recommendations for fan energy reduction via demand-based static pressure reset down to 2/3 of duct static pressure set point, "VSD 2/3 Reset."

#### Inputs:

Analog inputs shall monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:

0-10 VDC Sensors  
1000ohm RTDs  
NTC Thermistors

Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input "bouncing."

For noise immunity, the inputs shall be internally isolated from power, communications, and output circuits.

#### Outputs

Analog outputs shall provide the following control outputs:

0-10 VDC

Binary outputs shall provide a SPST Triac output rated for 500mA at 24 VAC.

For noise immunity, the outputs shall be internally isolated from power, communications, and other output circuits.

## HVAC Input Devices

### General Requirements

Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.

### Temperature Sensors

General Requirements:

Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.

The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD.

The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:

Point Type	Accuracy
Chilled Water	$\pm .5^{\circ}\text{F}$ .
Room Temp	$\pm .5^{\circ}\text{F}$ .
Duct Temperature	$\pm .5^{\circ}\text{F}$ .
All Others	$\pm .75^{\circ}\text{F}$ .

#### Room Temperature Sensors with Integral Display

Room sensors shall be constructed for either surface or wallbox mounting.

Room sensors shall have an integral LCD display and four button keypad with the following capabilities:

Display room and outside air temperatures.

Display and adjust room comfort setpoint.

Display and adjust fan operation status.

Timed override request push button with LED status for activation of after-hours operation.

Display controller mode.

Password selectable adjustment of setpoint and override modes.

#### Thermowells

When thermowells are required, the sensor and well shall be supplied as a complete assembly, including well head and Greenfield fitting.

Thermowells shall be pressure rated and constructed in accordance with the system working pressure.

Thermowells and sensors shall be mounted in a threadolet or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement.

Thermowells shall be constructed of 316 stainless steel.

#### Outside Air Sensors

Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.

Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.

Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.

#### Duct Mount Sensors

Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.

Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.

For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.

#### Averaging Sensors

For ductwork greater in any dimension than 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.

For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.

Capillary supports at the sides of the duct shall be provided to support the sensing string.

#### Humidity Sensors

The sensor shall be a solid state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.

The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.

The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion.

Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealtite fittings and stainless steel bushings.

A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.

Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.

#### Differential Pressure Transmitters

##### General Air and Water Pressure Transmitter Requirements:

Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.

Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.

Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.

A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.

##### Low Differential Water Pressure Applications (0" - 20" w.c.)

The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points.

The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

.01-20" w.c. input differential pressure range.

4-20 mA output.

Maintain accuracy up to 20 to 1 ratio turndown.

Reference Accuracy: +0.2% of full span.

#### Medium to High Differential Water Pressure Applications (Over 21" w.c.)

The differential pressure transmitter shall meet the low pressure transmitter specifications with the following exceptions:

Differential pressure range 10" w.c. to 300 PSI.

Reference Accuracy:  $\pm 1\%$  of full span (includes non-linearity, hysteresis, and repeatability).

Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

#### Building Differential Air Pressure Applications (-1" to +1" w.c.)

The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.

The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

-1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application)

4-20 mA output.

Maintain accuracy up to 20 to 1 ratio turndown.

Reference Accuracy: +0.2% of full span.

#### Low Differential Air Pressure Applications (0" to 5" w.c.)

The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.

The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

(0.00 - 1.00" to 5.00") w.c. input differential pressure ranges. (Select range appropriate for system application.)

4-20 mA output.

Maintain accuracy up to 20 to 1 ratio turndown.

Reference Accuracy: +0.2% of full span.

#### Medium Differential Air Pressure Applications (5" to 21" w.c.)

The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:  
Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.  
Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG).  
Thermal Effects: <+.033 F.S./Deg. F. over 40°F. to 100°F. (calibrated at 70°F.).

Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

#### Flow Monitoring

##### Static Pressure Traverse Probe

Duct static probes shall be provided where required to monitor duct static pressure.

#### Status and Safety Switches

##### General Requirements

Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the FMS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.

##### Current Sensing Switches

The current sensing switch shall be self-powered with solid state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.

Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.

Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.

##### Air Filter Status Switches

Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC. A complete installation kit shall be provided, including: static pressure taps, tubing, fittings, and air filters.

Provide appropriate scale range and differential adjustment for intended service.

##### Air Flow Switches

Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.

#### Air Pressure Safety Switches

Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.

Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.

#### Low Temperature Limit Switches

The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.

The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.

For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.

### HVAC Output Devices

#### Actuators

##### General Requirements

Damper and valve actuators shall be electronic.

##### Electronic Damper Actuators

Electronic damper actuators shall be direct shaft mount.

Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.

Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.

Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as “quick acting,” shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.

#### Electronic Valve Actuators

Electronic valve actuators shall be manufactured by the valve manufacturer. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.

Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized based on valve manufacturer’s recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.

Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.

Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.

#### Control Dampers

The Equipment Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the Equipment Contractor or as specifically indicated on the Drawings.

All dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.

All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.

Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 48". Damper blades shall be 16-gauge minimum and shall not exceed six (6) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. Additional stiffening or bracing shall be provided for any section exceeding 48" in height. All damper bearings shall be made of stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48"x48" size shall not leak in excess of 8.5 cfm per square foot when closed against 4" w.g. static pressure when tested in accordance with AMCA Std. 500.

Air foil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5" w.g., but no more than 4000 FPM or 6" w.g.

One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below.

Multiple section dampers may be jack-shafted to allow mounting of direct connect electronic actuators. Each end of the jack shaft shall receive at least one actuator to reduce jack shaft twist.

#### Control Relays

##### Control Pilot Relays

Control pilot relays shall be of a modular plug-in design with retaining springs or clips.

Mounting bases shall be snap-mount.

DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.

Contacts shall be rated for 10 amps at 120VAC.

Relays shall have an integral indicator light and check button.

#### Control Valves

All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule elsewhere in this Specification.

Chilled water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer's recommendations for the given application. In general, valves (2 or 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 PSI. Valves (3-way) serving constant flow air handling unit coils

with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no less than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.

Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all hot and chilled water applications, except those described hereinafter. The valve discs shall be composition type. Valve stems shall be stainless steel.

Ball valves shall be acceptable for water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units.

Butterfly valves shall be acceptable for modulating large flow applications greater than modulating plug valves, and for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, replaceable lining suitable for temperature of system, and a stainless steel vane. Valves for modulating service shall be sized and travel limited to 50 degrees of full open. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight.

#### Electronic Signal Isolation Transducers

A signal isolation transducer shall be provided whenever an analog output signal from the Facility Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input signal from a remote system.

The signal isolation transducer shall provide ground plane isolation between systems.

Signals shall provide optical isolation between systems.

### HVAC Miscellaneous Devices

#### Local Control Panels

All control panels shall be factory constructed, incorporating the FMS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance. Control panels shall be fully enclosed, with sub-panel, hinged door, and key-locking latch.

In general, the control panels shall consist of the DDC controller(s), display module, and I/O devices—such as relays, transducers, and so forth—that are not required to be located external to the control panel due to function. The display module shall be flush mounted in the panel face unless otherwise noted.

All I/O connections on the DDC controller shall be extended to a numbered, color-coded, and labeled terminal strip for ease of maintenance and expansion. Wiring to I/O devices shall be made from this terminal strip.

All other wiring in the panel, internal and external, shall be made to additional line or low voltage color-coded and labeled terminal strips. Low and line voltage wiring shall be segregated. All terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.

All wiring for every control panel shall follow a common color-coded format. All terminal strip color coding and numbering shall follow a common format. All wiring shall be neatly installed in plastic trays or tie-wrapped.

A convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers.

#### Power Supplies

DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.

Input: 120 VAC +10%, 60Hz.

Output: 24 VDC.

Line Regulation: +0.05% for 10% line change.

Load Regulation: +0.05% for 50% load change.

Ripple and Noise: 1 mV rms, 5 mV peak to peak.

An appropriately sized fuse and fuse block shall be provided and located next to the power supply.

A power disconnect switch shall be provided next to the power supply.

#### Thermostats

Electric room thermostats of the heavy-duty type shall be provided for unit heaters, cabinet unit heaters, and ventilation fans, where required. All these items shall be provided with concealed adjustment. Finish of covers for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer's standard finish.

### Performance / Execution

#### FMS Specific Requirements

##### Actuation / Control Type

###### Primary Equipment

Controls shall be provided by equipment manufacturer as specified herein.

All damper and valve actuation shall be electric or Pneumatic as indicated.

###### Air Handling Equipment

All air handlers shall be controlled with HVAC Node (DDC controller)

All damper and valve actuation shall be electric or Pneumatic as indicated.

###### Terminal Equipment:

Terminal Units (VAV, UV, etc.) shall have electric damper and valve actuation.

All Terminal Units shall be controlled with HVAC Node (DDC controller)

**Comment [JC111]:** Modify this section to fit the project requirements for electric or pneumatic actuation and DDC vs. stat control, etc. Specify pilot positioners, spring return, etc. as necessary.

## Installation Practices

### FMS Wiring

All conduit, wiring, accessories and wiring connections required for the installation of equipment to the Facility Management System, as herein specified, shall be provided by the equipment Contractor unless specifically shown on the Electrical Drawings under Division 16 Electrical. All wiring shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes, unless specified otherwise in this section.

All FMS wiring materials and installation methods shall comply with FMS manufacturer recommendations.

The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the equipment Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the equipment Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.

### Class 2 Wiring

All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.

Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5' from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.

Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.

Perform circuit tests using qualified personnel only. Provide complete testing for all cables used under this Contract. Provide all equipment, tools, and personnel as necessary to conduct these tests.

Provide for complete grounding of all signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.

### FMS Line Voltage Power Source

120-volt AC circuits used for the Facility Management System shall be taken from panelboards and circuit breakers provided by Division 16.

Circuits used to communicate with the FMS shall be dedicated to the FMS and shall not be used for any other purposes.

DDC terminal unit controllers may use AC power from motor power circuits.

### FMS Raceway

All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2".

Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.

All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.

Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

#### Penetrations

Provide firestopping for all penetrations used by dedicated FMS conduits and raceways. All other project firestopping to be by other trade.

All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.

All wiring passing through penetrations, including walls, shall be in conduit or enclosed raceway.

Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

No penetrations in structural elements shall be made before receipt of written approval from the Physical Plant.

#### FMS Identification Standards

Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.

Each of the cable types specified in Item A shall be of a different color coding for easy identification and troubleshooting.

**Comment [JC112]:** Cable colors to be confirmed with appropriate standards

#### FMS Node Installation

The FMS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor.

Each cabinet shall be anchored per the manufacturer's recommendations.

The FMS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.

#### Input Devices

All Input devices shall be installed per the manufacturer recommendation

Locate components of the FMS in accessible local control panels wherever possible.

#### HVAC Input Devices – General

All Input devices shall be installed per the manufacturer recommendation

Locate components of the FMS in accessible local control panels wherever possible.

The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.

Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.

#### Outside Air Sensors

Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.

Sensors shall be installed with a rain proof, perforated cover.

#### Water Differential Pressure Sensors

Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.

Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.

The transmitters shall be installed in an accessible location wherever possible.

#### Medium to High Differential Water Pressure Applications (Over 21" w.c.):

Air bleed units, bypass valves and compression fittings shall be provided.

#### Building Differential Air Pressure Applications (-1" to +1" w.c.):

Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.

The interior tip shall be inconspicuous and located as shown on the drawings.

#### Duct Temperature Sensors:

Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.

The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.

For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.

The sensor shall be mounted to suitable supports using factory approved element holders.

#### Space Sensors:

Shall be mounted per ADA requirements.

Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.

#### Low Temperature Limit Switches:

Install on the discharge side of the first water or steam coil in the air stream.

Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.

For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.

**Air Differential Pressure Status Switches:**

Install with static pressure tips, tubing, fittings, and air filter.

**Water Differential Pressure Status Switches:**

Install with shut off valves for isolation.

**HVAC Output Devices**

All output devices shall be installed per the manufacturers recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, air flow stations, pressure wells, etc.

**Actuators:** All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.

**Control Dampers:** Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.

**Control Valves:** Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.

**Electronic Signal Isolation Transducers:** Whenever an analog output signal from the Facility Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems

**Comment [JCI13]:** Edit or delete according to specific project requirements

**Commissioning**

Fully commission all aspects of the Facility Management System work.

**Acceptance Check Sheet**

Submit the check sheet to the Physical Plant for approval

Physical Plant will use the check sheet as the basis for acceptance with the FMS Contractor.

**VAV box performance verification and documentation:**

The FMS Contractor shall test each VAV box for where the dampers in one half of a group of boxes are stepped towards full open while the other half are stepped towards full closed. At each step, after a settling time, box air flows and damper positions will be sampled. Following the cycle, a pass/fail report indicating results shall be produced. Possible results are Pass, No change in flow between full open and full close, Reverse operation or Maximum flow not achieved. The report shall be submitted as documentation of the installation.

The FMS Contractor shall issue a report based on a sampling of the VAV calculated loop performance metrics. The report shall indicate performance criteria, include the count of conforming and non-conforming boxes, list the

non-conforming boxes along with their performance data, and shall also include graphical representations of performance.

Promptly rectify all listed deficiencies and submit to the Engineer that this has been done.

## Definitions

- Analog:** A continuously variable system or value not having discrete levels. Typically exists within a defined range of limiting values.
- Binary:** A two-state system where an “ON” condition is represented by one discrete signal level and an “OFF” condition is represented by a second discrete signal level each separated by a defined deadband.
- Facility Management System (FMS):** The total integrated system of fully operational and functional elements, including equipment, software, programming, and associated materials, to be provided by this Division FMS Contractor and to be interfaced to the associated work of other related trades.
- FMS Contractor:** The single Contractor to provide the work of this Division. This Contractor shall be the primary manufacturer, installer, commissioner and ongoing service provider for the FMS work.
- Control Sequence:** An FMS pre-programmed arrangement of software algorithms, logical computation, target values and limits as required to attain the defined operational control objectives.
- Direct Digital Control:** The digital algorithms and pre-defined arrangements included in the FMS software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional, Derivative and Integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.
- FMS Network:** The total digital on-line real-time interconnected configuration of FMS digital processing units, workstations, panels, sub-panels, controllers, devices and associated elements individually known as network nodes. May exist as one or more fully interfaced and integrated sub-networks, LAN, WAN or the like.
- Node:** A digitally programmable entity existing on the FMS network.
- FMS Integration:** The complete functional and operational interconnection and interfacing of all FMS work elements and nodes in compliance with all applicable codes, standards and ordinances so as to provide a single coherent FMS as required by this Division.
- Provide:** The term “Provide” and its derivatives when used in this Division shall mean to furnish, install in place, connect, calibrate, test, commission, warrant, document and supply the associated required services ready for operation.
- PC:** IBM-compatible Personal Computer from a recognized major manufacturer. PC “clones” are not acceptable.
- Furnish:** The term “Furnish” and its derivatives when used in this Division shall mean supply at the FMS Contractor’s cost to the designated third party trade contractor for installation. FMS Contractor shall connect furnished items to the FMS, calibrate, test, commission, warrant and document.
- Wiring:** The term “Wiring” and its derivatives when used in this Division shall mean provide the FMS wiring and terminations.
- Install:** The term “Install” and its derivatives when used in this Division shall mean receive at the jobsite and mount.

Protocol: The term “protocol” and its derivatives when used in this Division shall mean a defined set of rules and standards governing the on-line exchange of data between FMS network nodes.

Software: The term “software” and its derivatives when used in this Division shall mean all of programmed digital processor software, preprogrammed firmware and project specific digital process programming and database entries and definitions as generally understood in the FMS industry for real-time, on-line, integrated FMS configurations.

The use of words in the singular in these Division documents shall not be considered as limiting when other indications in these documents denote that more than one such item is being referenced.

The following abbreviations and acronyms may be used in describing the work of this Division:

ADC	-	Analog to Digital Converter
AI	-	Analog Input
AN	-	Application Node
ANSI	-	American National Standards Institute
AO	-	Analog Output
ASCII -	American Standard Code for Information Interchange	
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers	
AWG -	American Wire Gauge	
CPU	-	Central Processing Unit
CRT	-	Cathode Ray Tube
DAC	-	Digital to Analog Converter
DDC	-	Direct Digital Control
DI	-	Digital Input
DO	-	Digital Output
EEPROM	-	Electronically Erasable Programmable Read Only Memory
EMI	-	Electromagnetic Interference
FAS	-	Fire Alarm Detection and Annunciation System
GUI	-	Graphical User Interface
HOA	-	Hand-Off-Auto
ID	-	Identification
IEEE	-	Institute of Electrical and Electronics Engineers
I/O	-	Input/Output
LAN	-	Local Area Network
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode
MCC	-	Motor Control Center
NC	-	Normally Closed
NIC	-	Not In Contract
NO	-	Normally Open
OWS	-	Operator Workstation
OAT	-	Outdoor Air Temperature
PC	-	Personal Computer
RAM	-	Random Access Memory

RF	-	Radio Frequency
RFI	-	Radio Frequency Interference
RH	-	Relative Humidity
ROM	-	Read Only Memory
RTD	-	Resistance Temperature Device
SPDT	-	Single Pole Double Throw
SPST	-	Single Pole Single Throw
XVGA	-	Extended Video Graphics Adapter
TBA	-	To Be Advised
TCP/IP	-	Transmission Control Protocol/Internet Protocol
TTD	-	Thermistor Temperature Device
UPS	-	Uninterruptible Power Supply
VAC	-	Volts, Alternating Current
VAV	-	Variable Air Volume
VDC	-	Volts, Direct Current
WAN	-	Wide Area Network