1. GENERAL

1.1 General Intent and Related Information

.1 All work of this Division shall be coordinated and provided by the single Building Management System (BMS) Contractor.

.2 The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference the Mechanical Division Sections for details.

.3 The work of this Division shall be as required by the Specifications, Point Schedules and Drawings.

.4 If the BMS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

.5 The City has a central monitoring system in place, and is currently monitoring building points at 457 Main St., Winnipeg, Manitoba (Confederation Building). These existing points are being monitored using the Johnson Controls N2 communications protocol DDC controllers, via the City supplied leased line modem network. Unless otherwise stated, these points shall remain as-is.

.6 Where new DDC points are identified in this specification to be centrally monitored points, the controls contractor shall provide and install the required N2 protocol capable hardware and software to interface these points, and where required, extended the existing N2 trunk to any new DDC controllers. It is the controls contractors' responsibility to integrate any new DDC points into the City's existing Johnson Controls Metasys EA servers and workstations. These servers and workstations are located at 510 Main St. Winnipeg, MB. No new operator work stations are required under this contract.

1.2 Definitions

.1 Analog: A continuously variable system or value not having discrete levels. Typically exists within a defined range of limiting values.

.2 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.

.3 Building Management System (BMS): The total integrated system of fully operational and functional elements, including equipment, software, programming, and associated materials, to be provided by this Division BMS Contractor and to be interfaced to the associated work of other related trades.

.4 BMS 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 BMS work.

.5 Control Sequence: An BMS pre-programmed arrangement of software algorithms, logical computation, target values and limits as required to attain the defined operational control objectives.

.6 Direct Digital Control: The digital algorithms and pre-defined arrangements included in the BMS 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.

.7 BMS Network: The total digital on-line real-time interconnected configuration of BMS 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.

.8 Node: A digitally programmable entity existing on the BMS network.

.9 BMS Integration: The complete functional and operational interconnection and interfacing of all BMS work elements and nodes in compliance with all applicable codes, standards and ordinances so as to provide a single coherent BMS as required by this Division.

.10 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.

.11 PC: IBM-compatible Personal Computer from a recognized major manufacturer

.12 Furnish: The term “Furnish” and its derivatives when used in this Division shall mean supply at the BMS Contractor’s cost to the designated third party trade contractor for installation. BMS Contractor shall connect furnished items to the BMS, calibrate, test, commission, warrant and document.

.13 Wiring: The term “Wiring” and its derivatives when used in this Division shall mean provide the BMS wiring and terminations.

.14 Install: The term “Install” and its derivatives when used in this Division shall mean receive at the jobsite and mount.

.15 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 BMS network nodes.

.16 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 BMS industry for real-time, on-line, integrated BMS configurations.

.17 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.

.18 Headings, paragraph numbers, titles, shading, bolding, underscores, clouds and other symbolic interpretation aids included in the Division documents are for general information only and are to assist in the reading and interpretation of these Documents.

.19 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

1.3 BMS Description

.1 The Building Management System (BMS) shall be a complete system designed for use with the enterprise IT systems in place at the City of Winnipeg. This functionality shall extend into the equipment rooms. Devices residing on the automation network located in equipment rooms and similar shall be fully IT compatible devices that mount and communicate directly on the IT infrastructure in the facility. Contractor shall be responsible for coordination with the City's IT staff to ensure that the FMS will perform in the City's environment without disruption to any of the other activities taking place on that LAN.

.2 All points of user interface shall be on standard PCs that do not require the purchase of any special software from the BMS manufacturer for use as a building operations terminal. The primary point of interface on these PCs will be a standard Web Browser.

.3 Where necessary and as dictated elsewhere in these Specifications, the City of Winnipeg's existing ADS/ADX Server(s) shall be used for the purpose of providing a location for extensive archiving of system configuration data, and historical data such as trend data and operator transactions.

.4 The work of the single BMS Contractor shall be as defined individually and collectively in all Sections of this Division specification together with the associated Point Sheets and Drawings and the associated interfacing work as referenced in the related documents.

.5 The BMS work shall consist of the provision of all labour, 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 BMS.

.6 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 this Project.

.7 Manage and coordinate the BMS work in a timely manner in consideration of the Project schedules. Coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.

.8 The BMS as provided shall incorporate, at minimum, the following integrated features, functions and services:

.1 Operator information, alarm management and control functions.

.2 Enterprise-level information and control access.

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

.4 Diagnostic monitoring and reporting of BMS functions.

.5 Offsite monitoring and management access.

.6 Energy management

.7 Standard applications for terminal HVAC systems.

1.4 Quality Assurance

.1 General

.1 The following companies are approved Controls Contractors:

.1 Johnson Controls Branch Office

.2 Workplace Safety and Hazardous Materials

.1 Provide a safety program in compliance with the Contract Documents.

.2 The FMS Contractor shall have a corporately certified comprehensive Safety Certification Manual and a designated Safety Supervisor for the Project.

.3 The Contractor and its employees and subtrades comply with federal, state and local safety regulations.

.4 The Contractor shall ensure that all subcontractors and employees have written safety programs in place that covers their scope of work, and that their employees receive the training required by the OSHA have jurisdiction for at least each topic listed in the Safety Certification Manual.

.5 Hazards created by the Contractor or its subcontractors shall be eliminated before any further work proceeds.

.6 Hazards observed but not created by the Contractor or its subcontractors shall be reported to either the General Contractor or the City within the same day. The Contractor shall be required to avoid the hazard area until the hazard has been eliminated.

.7 The Contractor shall sign and date a safety certification form prior to any work being performed, stating that the Contractors' company is in full compliance with the Project safety requirements.

.8 The Contractor's safety program shall include written policy and arrangements for the handling, storage and management of all hazardous materials to be used in the work in compliance with the requirements of the AHJ at the Project site.

.9 The Contractor's employees and subcontractor's staff shall have received training as applicable in the use of hazardous materials and shall govern their actions accordingly.

1.5 References

.1 General

.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)

.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)

.23 ANSI/EIA 909.1-A-1999 (LonWorks)

.24 ANSI/ASHRAE Standard 195-2004 (BACnet)

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

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

1.6 Work by Others

.1 The demarcation of work and responsibilities between the BMS Contractor and other related trades shall be as outlined in the BMS RESPONSIBILITY MATRIX

BMS RESPONSIBILITY MATRIX				
Scope of Work	**FURNISH**	**INSTALL**	**Low Volt. WIRING/TUBE**	**LINE POWER**
BMS low voltage and communication wiring	BMS	BMS	BMS	N/A
BMS conduits and raceway	BMS	BMS	BMS	BMS
Automatic dampers	BMS	23	N/A	N/A
Manual valves	23	23	N/A	N/A
Automatic valves	BMS	23	BMS	N/A
Pipe insertion devices and taps including thermowells, flow and pressure stations.	BMS	23	BMS	BMS
BMS Current Switches.	BMS	BMS	BMS	N/A
BMS Control Relays	BMS	BMS	BMS	N/A
All BMS Nodes, equipment, housings, enclosures and panels.	BMS	BMS	BMS	BMS
Fire/Smoke Dampers	23	23	BMS	26

Fire Dampers	23	23	N/A	N/A
Boiler wiring	23	23	23	23
VFD	BMS	26	BMS	26
Refrigerant monitors	23	BMS	BMS	26
Fire Alarm shutdown relay interlock wiring	26	26	26	26
Fire Alarm smoke control relay interlock wiring	26	26	26	26
Packaged RTU space mounted controls	23*	BMS	BMS	26
Packaged RTU field-mounted controls	BMS	BMS	BMS	26
Starters, HOA switches	26	26	N/A	26
Control damper actuators	BMS	BMS	BMS	26

1.7 Submittals

.1 Shop Drawings, Product Data, and Samples

.1 The BMS contractor shall submit a list of all Shop Drawings with submittals dates within thirty (30) days of contract award.

.2 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 City and the Contract Administrator for Contract compliance.

.3 Allow fifteen (15) working days for the review of each package by the Contract Administrator in the scheduling of the total BMS work.

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

.5 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.

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

.7 At a minimum, submit the following:

.1 BMS network architecture diagrams including all nodes and interconnections.

.2 Systems schematics, sequences and flow diagrams.

.3 Points schedule for each point in the BMS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.

.4 Samples of Graphic Display screen types and associated menus.

.5 Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.

.6 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, Duct Size, Damper Size, Mounting, and Actuator Type.

.7 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, Design Pressure, and Actuator Type.

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

.9 Details of all BMS interfaces and connections to the work of other trades.

.10 Product data sheets or marked catalog pages including part number, photo and description for all products including software.

1.8 Record Documentation

.1 Operation and Maintenance Manuals

.1 Three (3) copies of the Operation and Maintenance Manuals shall be provided to the City's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BMS provided:

.1 Table of contents.

.2 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.

.3 Manufacturers product data sheets or catalog pages for all products including software.

.4 System Operator's manuals.

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

.6 BMS network diagrams.

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

.2 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.

1.9 Warranty

.1 Standard Material and Labour Warranty:

.1 Provide a one-year labour and material warranty on the BMS.

.2 If within twelve (12) months from the date of acceptance of product, upon written notice from the City, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BMS Contractor at the cost of the BMS Contractor.

2. PRODUCTS

2.1 General Description

.1 The Building Management System (BMS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other City provided networks.

.2 The Building Management System shall consist of the following:

.1 Standalone Network Automation Engine(s)

.2 Field Equipment Controller(s)

.3 Input/Output Module(s)

.4 Local Display Device(s)

.5 Network processing, data storage and communications equipment

.6 Other components required for a complete and working BMS

.3 The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.

.4 System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

.5 Acceptable Manufacturers

.1 Johnson Controls Metasys Extended Architecture

2.2 BMS Architecture

.1 Automation Network

.1 The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard “off the shelf” products available through normal PC vendor channels.

.2 The BMS shall network multiple user interface clients, automation engines, system controllers and application-specific controllers. Provide application and data server(s) as required for systems operation.

.3 The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.

.4 Network Automation Engines (NAE) shall reside on the automation network.

.5 The automation network will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.

.6 The City shall provide all private and public telephones lines, ISDN lines and Internet Service Provider services and connections as necessary for the Controls Contractor to complete the work as contracted at the City’s direct cost. The Controls Contractor shall identify the specific requirements in their shop drawing submittal.

.2 Control Network

.1 Network Automation Engines shall provide supervisory control over the control network and shall support all three (3) of the following communication protocols:

.1 BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.

.2 LonWorks enabled devices using the Free Topology Transceiver (FTT-10a).

.3 The Johnson Controls N2 Field Bus.

.2 Control networks shall provide either “Peer-to-Peer,” Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.

.3 DDC Controllers shall reside on the control network.

.4 Control network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, or Johnson Controls N2 Field Bus.

.5 A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.

.6 BACnet Protocol Integration - BACnet

.1 The neutral protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-2003.

.2 A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.

.3 The ability to command, share point object data, change of state (COS) data and schedules between the host and BACnet systems shall be provided.

2.3 Network Automation Engines (NAE)

.1 Network Automation Engine (NAE)

.1 The Network Automation Engine (NAE) shall be a fully user-programmable, supervisory controller. The NAE 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 Automation Engines.

.2 Automation network – The NAE shall reside on the automation network and shall support a subnet of system controllers.

.3 User Interface – Each NAE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.

.1 The web based UI software shall be imbedded in the NAE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.

.2 The NAE shall support up four (4) concurrent users.

.3 The web based user shall have the capability to access all system data through one NAE.

.4 Remote users connected to the network through an Internet Service Provider (ISP) or telephone dial up shall also have total system access through one NAE.

.5 Systems that require the user to address more than one NAE to access all system information are not acceptable.

.6 The NAE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NAE.

.7 Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.

.8 The web based UI shall support the following functions using a standard version of Microsoft Internet Explorer:

.1 Configuration

.2 Commissioning

.3 Data Archiving

.4 Monitoring

.5 Commanding

.6 System Diagnostics

.9 Systems that require workstation software or modified web browsers are not acceptable.

.10 The NAE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.

.4 Processor – The NAE shall be microprocessor-based with a minimum word size of 32 bits. The NAE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NAE size and capability shall be sufficient to fully meet the requirements of this Specification.

.5 Memory – Each NAE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.

.6 Hardware Real Time Clock – The NAE shall include an integrated, hardware-based, real-time clock.

.7 The NAE shall include troubleshooting LED indicators to identify the following conditions:

.1 Power - On/Off

.2 Ethernet Traffic – Ethernet Traffic/No Ethernet Traffic

.3 Ethernet Connection Speed – 10 Mbps/100 Mbps

.4 FC Bus – Normal Communications/No Field Communications

.5 Peer Communication – Data Traffic Between NAE Devices

.6 Run – NAE Running/NAE In Start-up/NAE Shutting Down/Software Not Running

.7 Bat Fault – Battery Defective, Data Protection Battery Not Installed

.8 Fault – General Fault

.9 Modem RX – NAE Modem Receiving Data

.10 Modem TX – NAE Modem Transmitting Data

.8 Communications Ports – The NAE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.

.1 Up to two (2) USB port

.2 Up to two (2) URS-232 serial data communication port

.3 Up to two (2) RS-485 port

.4 One (1) Ethernet port

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

.10 Power Failure – In the event of the loss of normal power, The NAE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.

.1 During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.

.2 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.

.11 Certification – The NAE shall be listed by Underwriters Laboratories (UL).

.12 Controller network – The NAE shall support the following communication protocols on the controller network:

.1 The NAE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.

.1 A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.

.2 The Conformance Statements shall be submitted 10 day prior to bidding.

.3 The NAE shall support a minimum of 100 control devices.

.2 The NAE shall support LonWorks enabled devices using the Free Topology Transceiver FTT10.

.1 All LonWorks controls devices shall be LonMark certified.

.2 The NAE shall support a minimum of 255 LonWorks enabled control devices.

.3 The NAE shall support the Johnson Controls N2 Field Bus.

.1 The NAE shall support a minimum of 100 N2 control devices.

.2 The Bus shall conform to Electronic Industry Alliance (EIA) Standard RS-485.

.3 The Bus shall employ a master/slave protocol where the NAE is the master.

.4 The Bus shall employ a four (4) level priority system for polling frequency.

.5 The Bus shall be optically isolated from the NAE.

.6 The Bus shall support the Metasys Integrator System.

2.4 DDC System Controllers

.1 Digital Controller w/ extension capability (DX)

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

.2 DX 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.

.1 Single boiler or chiller plants with pump logic.

.2 Cooling towers.

.3 Large, built-up Air Handling Units for special applications.

.4 Generic system interlocking through hardware.

.3 Point types – Each DX shall support the following types of point inputs and outputs:

.1 Analog inputs shall monitor the following analog signals:

.1 4-20 mA Sensors

.2 0-10 VDC Sensors

.3 1000 ohm RTDs

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

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

.4 Analog outputs shall provide the following control outputs:

.1 4.20 mA – Sink or Source

.2 0-10 VDC

.5 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.

.6 Tri-state 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.

.4 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.

.5 Power fail 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.

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

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

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

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

.2 Analog Outputs – 0-10V, 4-20mA

.3 Digital Inputs w/ digital counter

.4 Digital Outputs – triacs or relay contacts

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

.2 Unitary Controllers (UNT)

.1 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.

.2 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:

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

.2 Heat Pumps (Air-to-Air, Water-to-Air).

.3 Packaged Rooftops.

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

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

.1 Analog inputs shall monitor the following analog signals:

.1 0-10 VDC Sensors

.2 1000 ohm RTDs

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

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

.4 Analog outputs shall provide the following control outputs:

.1 0-10 VDC

.5 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.

.6 Tri-state 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.

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

.4 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.

.5 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.

.6 Power fail 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.

.3 VAV Modular Assembly (VMA)

.1 The VAV Modular Assembly shall provide both standalone and networked direct digital control of pressure-independent, variable air volume terminal units. It shall address both single and dual duct applications.

.2 The VAV Modular Assembly 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.

.3 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.

.4 The controller 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.

.5 Each controller shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.

.6 The controller shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.

.7 Each controller 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.

.8 The controller 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.

.9 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.

.10 The controller firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.

.11 The VMA shall include troubleshooting LED indicators to identify the following conditions:

.1 Power On

.2 Power Off

.3 VMA Off Line

.4 VMA Replacement

.5 VMA Corrupted Memory

.12 The controller shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.

.13 The controller 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.

.14 Controller 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.

.1 Absolute temperature loop error.

.2 Signed temperature loop error.

.3 Absolute airflow loop error.

.4 Signed airflow loop error.

.5 Average damper actuator duty cycle.

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

.1 Unreliable space temperature sensor.

.2 Unreliable differential pressure sensor.

.3 Starved box.

.4 Actuator stall

.5 Insufficient cooling.

.6 Insufficient heating.

.1 The controller shall provide a flow test function to view damper position vs. flow in a graphical format. The information would alert the user to check damper position. The VMA would also provide a method to calculate actuator duty cycle as an indicator of damper actuator runtime.

.16 The controller 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.

.17 The controller 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.

.18 Inputs:

.1 Analog inputs with user defined ranges shall monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:

.1 0-10 VDC Sensors

.2 1000 ohm RTDs

.3 NTC Thermistors

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

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

.4 Provide side loop application for humidity control.

.19 Outputs

.1 Analog outputs shall provide the following control outputs:

.1 0-10 VDC

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

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

.20 Application Configuration

.1 The VAV Modular Assembly shall be configured with a software tool that provides a simple Question/Answer format for developing applications and downloading.

.21 Sensor Support

.1 The VMA shall support an LCD display room sensor.

.2 The VMA shall also support standard room sensors as defined by analog input requirements.

.3 The VMA shall support humidity sensors defined by the AI side loop.

2.5 Input Devices

.1 General Requirements

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

.2 Temperature Sensors

.1 General Requirements:

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

.2 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.

.3 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°F.
Room Temp	$\pm$ .5°F.
Duct Temperature	$\pm$ .5°F.
All Others	$\pm$ .75°F.

.2 Room Temperature Sensors

.1 Room sensors shall be constructed for either surface or wall box mounting.

.2 Room sensors shall have the following options when specified:

.1 Setpoint reset slide switch providing a $\pm$3 degree (adjustable) range.

.2 Individual heating/cooling setpoint slide switches.

.3 A momentary override request push button for activation of after-hours operation.

.4 Analog thermometer.

.3 Room Temperature Sensors with Integral Display

.1 Room sensors shall be constructed for either surface or wall box mounting.

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

.1 Display room and outside air temperatures.

.2 Display and adjust room comfort setpoint.

.3 Display and adjust fan operation status.

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

.5 Display controller mode.

.6 Password selectable adjustment of setpoint and override modes.

.4 Thermo wells

.1 When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.

.2 Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.

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

.4 Thermo wells shall be constructed of 316 stainless steel.

.5 Outside Air Sensors

.1 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.

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

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

.6 Duct Mount Sensors

.1 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.

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

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

.7 Averaging Sensors

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

.2 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.

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

.8 Acceptable Manufacturers: Johnson Controls, Setra.

.3 Humidity Sensors

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

.2 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.

.3 The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH @ 77 Deg F unless specified elsewhere.

.4 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.

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

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

.7 Acceptable Manufacturers: Johnson Controls, Veris Industries, and Mamac.

.4 Differential Pressure Transmitters

.1 General Air and Water Pressure Transmitter Requirements:

.1 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.

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

.3 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 City permanent, easy-to-use connection.

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

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

.1 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.

.2 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 .01-20" w.c. input differential pressure range.

.2 4-20 mA output.

.3 Maintain accuracy up to 20 to 1 ratio turndown.

.4 Reference Accuracy: +0.2% of full span.

.3 Acceptable Manufacturers: Setra and Mamac.

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

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

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

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

.2 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.

.3 Acceptable Manufacturers: Setra and Mamac.

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

.1 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.

.2 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 -1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application)

.2 4-20 mA output.

.3 Maintain accuracy up to 20 to 1 ratio turndown.

.4 Reference Accuracy: +0.2% of full span.

.3 Acceptable Manufacturers: Johnson Controls and Setra.

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

.1 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.

.2 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 (0.00 - 1.00" to 5.00") w.c. input differential pressure ranges. (Select range appropriate for system application.)

.2 4-20 mA output.

.3 Maintain accuracy up to 20 to 1 ratio turndown.

.4 Reference Accuracy: +0.2% of full span.

.3 Acceptable Manufacturers: Johnson Controls and Setra.

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

.1 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:

.1 Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.

.2 Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG.

.3 Thermal Effects: <+.033 F.S./Deg. F. over 40°F. to 100°F. (calibrated at 70°F.).

.2 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.

.3 Acceptable manufacturers: Johnson Controls and Setra.

.5 Status and Safety Switches

.1 General Requirements

.1 Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the BMS 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.

.2 Current Sensing Switches

.1 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.

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

.3 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.

.4 Acceptable manufacturers: Veris Industries

.3 Air Filter Status Switches

.1 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.

.2 A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.

.3 Provide appropriate scale range and differential adjustment for intended service.

.4 Acceptable manufacturers: Johnson Controls, Cleveland Controls

.4 Air Flow Switches

.1 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.

.2 Acceptable manufacturers: Johnson Controls, Cleveland Controls

.5 Air Pressure Safety Switches

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

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

.3 Acceptable manufacturers: Johnson Controls, Cleveland Controls

.6 Water Flow Switches

.1 Water flow switches shall be equal in accordance with B6 to the Johnson Controls P74.

.7 Low Temperature Limit Switches

.1 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.

.2 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.

.3 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.

.4 The low temperature limit switch shall be equal in accordance with B6 to Johnson Controls A70.

2.6 Output Devices

.1 Actuators

.1 General Requirements

.1 Damper and valve actuators shall be electronic and/or pneumatic, as specified in the System Description section.

.2 Electronic Damper Actuators

.1 Electronic damper actuators shall be direct shaft mount.

.2 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.

.3 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.

.4 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.

.5 Acceptable manufacturers: Johnson Controls, Mamac.

.3 Electronic Valve Actuators

.1 Electronic valve actuators shall be manufactured by the valve manufacturer.

.2 Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.

.3 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.

.4 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.

.5 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.

.6 Acceptable manufacturers: Johnson Controls

.2 Control Dampers

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

.2 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.

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

.4 Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60". Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, 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 8.0 cfm per square foot when closed against 4" w.g. static pressure when tested in accordance with AMCA Std. 500.

.5 Airfoil 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. Acceptable manufacturers are Johnson Controls D-7250 D-1250 or D-1300, Ruskin CD50, and Vent Products 5650.

.6 One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below. Acceptable manufacturers are: Johnson Controls D-1600, Ruskin CD36, and Vent Products 5800.

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

.3 Control Relays

.1 Control Pilot Relays

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

.2 Mounting Bases shall be snap-mount.

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

.4 Contacts shall be rated for 10 amps at 120VAC.

.5 Relays shall have an integral indicator light and check button.

.6 Acceptable manufacturers: Johnson Controls, Lectro

.2 Lighting Control Relays

.1 Lighting control relays shall be latching with integral status contacts.

.2 Contacts shall be rated for 20 amps at 277 VAC.

.3 The coil shall be a split low-voltage coil that moves the line voltage contact armature to the ON or OFF latched position.

.4 Lighting control relays shall be controlled by:

.1 Pulsed Tri-state Output – Preferred method.

.2 Pulsed Paired Binary Outputs.

.3 A Binary Input to the Facility Management System shall monitor integral status contacts on the lighting control relay. Relay status contacts shall be of the "dry-contact" type.

.5 The relay shall be designed so that power outages do not result in a change-of-state, and so that multiple same state commands will simply maintain the commanded state. Example: Multiple OFF command pulses shall simply keep the contacts in the OFF position.

.4 Control Valves

.1 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.

.2 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.

.3 Ball valves shall be used for hot and chilled water applications, water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units except those described hereinafter.

.4 Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all special applications as indicated on the valve schedule. Valve discs shall be composition type. Valve stems shall be stainless steel.

.5 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.

.6 Acceptable manufacturers: Johnson Controls

.5 Electronic Signal Isolation Transducers

.1 A signal isolation transducer shall be provided whenever an analog output signal from the BMS 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.

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

.3 Signals shall provide optical isolation between systems.

.4 Acceptable manufacturers: Advanced Control Technologies

.6 External Manual Override Stations

.1 External manual override stations shall provide the following:

.1 An integral HAND/OFF/AUTO switch shall override the controlled device pilot relay.

.2 A status input to the Facility Management System shall indicate whenever the switch is not in the automatic position.

.3 A Status LED shall illuminate whenever the output is ON.

.4 An Override LED shall illuminate whenever the HOA switch is in either the HAND or OFF position.

.5 Contacts shall be rated for a minimum of 1 amp at 24 VAC.

.7 Electronic/Pneumatic Transducers

.1 Electronic to Pneumatic transducers shall provide:

.1 Output: 3-15 PSIG.

.2 Input: 4-20 mA or 0-10 VDC.

.3 Manual output adjustment.

.4 Pressure gauge.

.5 External replaceable supply air filter.

.6 Acceptable manufacturers: Johnson Controls, Mamac

2.7 Miscellaneous Devices

.1 Variable Frequency Motor Speed Control Drives (VFD). Where shown on the drawings, adjustable frequency drives 1 through 75 HP shall have the following features:

.1 The VFD shall be rated for 600 Vac (optional input voltages of 208, 240 Vac through 30 HP). The VFD shall provide microprocessor based control for three-phase induction motors. The controller's full load output current rating shall be based on variable torque application at 40° C ambient and 1-16 kHz switching frequency below 50 HP and 1-10 kHz 50 HP and above to reduce motor noise and avoid increased motor losses.

.2 The VFD shall be of the Pulse Width Modulated (PWM) design converting the utility input voltage and frequency to a variable voltage and frequency output via a two-step operation. Adjustable Current Source VFD are not accepted. Insulated Gate Bipolar Transistors (IGBTs) shall be used in the inverter section. Bipolar Junction Transistors, GTOs or SCRs are not accepted. The VFD shall run at the above listed switching frequencies.

.3 The VFD shall have an efficiency at full load and speed that exceeds 95% for VFD below 15 HP and 97% for drives 15 HP and above. The efficiency shall exceed 90% at 50% speed and load.

.4 The VFD shall maintain a minimum line side displacement power factor of 0.96, regardless of speed and load.

.5 The VFD shall have a one (1) minute overload current rating of 110% for variable torque applications.

.6 The VFD shall be capable of operating any NEMA design B squirrel cage induction motor, regardless of manufacturer, with a horsepower and current rating within the capacity of the VFD.

.7 The VFD shall have an integral EMI/RFI filter as standard.

.8 The VFD shall limit harmonic distortion reflected onto the utility system to voltage and current levels as defined by IEEE 519-1992 for general systems applications, by utilizing the standard 3% nominal impedance integral ac three-phase line reactor. DC link chokes are not accepted.

.9 Any harmonic calculations shall be done based on the kVA capacity, X/R ratio and the impedance of the utility transformer feeding the installation, as noted on the drawings, and the total system load. The calculations shall be made with the point of common coupling (PCC) being the point where the utility feeds multiple customers.

.10 Total harmonic distortion shall be calculated under worst case conditions in accordance with the procedure outlined in IEEE 519-1992. Copies of these calculations are to be made available upon request. The contractor shall provide any needed information to the VFD supplier three (3) weeks prior to requiring harmonic calculations.

.11 The system containing the VFD shall comply with the 5% level of total harmonic distortion of line voltage and the line current limits as defined in IEEE 519-1992. If the system cannot meet the harmonic levels with the VFD provided with the standard input line reactor or optional input isolation transformer, the VFD manufacturer shall supply an eighteen pulse, multiple bridge rectifier ac to dc conversion section with phase shifting transformer for all drives above 75 HP. This eighteen pulse rectifier converter shall result in a multiple pulse current waveform that will more nearly approximate a true sinewave to reduce voltage harmonic content on the utility line. The phase shifting transformer shall be of a single winding type to optimize its KVA rating and harmonic cancellation capability.

.1 Harmonic filters are not accepted above 75 HP.

.12 The VFD shall be able to start into a spinning motor. The VFD shall be able to determine the motor speed in any direction and resume operation without tripping. If the motor is spinning in the reverse direction, the VFD shall start into the motor in the reverse direction, bring the motor to a controlled stop, and then accelerate the motor to the preset speed.

.13 Standard operating conditions shall be:

.1 Incoming Power: Three-phase, 208 / 240 / 480 (+10% to -15%) and 50/60 Hz (+/- 5 Hz) power to a fixed potential DC bus level.

.2 Frequency stability of +/-0.05% for 24 hours with voltage regulation of +/-1% of maximum rated output voltage.

.3 Speed regulation of +/- 0.5% of base speed.

.4 Load inertia dependant carryover (ridethrough) during utility loss.

.5 Insensitive to input line rotation.

.6 Humidity: 0 to 95% (non-condensing and non-corrosive).

.7 Altitude: 0 to 3,300 feet (1000 meters) above sea level.

.8 Ambient Temperature: -10 to 40 °C (VT).

.9 Storage Temperature: -40 to 70 °C.

.14 Control Functions

.1 Frequently accessed VFD programmable parameters shall be adjustable from a digital operator keypad located on the front of the VFD. The VFD shall have a 3 line alphanumeric programmable display with status indicators. Keypads must use plain English words for parameters, status, and diagnostic messages. Keypads that are difficult to read or understand are not accepted, and particularly those that use alphanumeric code and tables. Keypads shall be adjustable for contrast with large characters easily visible in normal ambient light.

.2 The keypad shall include a Hand-Off-Auto membrane selection and an Inverter/Bypass membrane selection. When in “Hand” the VFD will be started and the speed will be controlled from the up/down arrows. When in “Off”, the VFD will be stopped. In “Auto”, the VFD will start via an external contact closure or a communication network and the VFD speed will be controlled via an external speed reference.

.3 The keypad shall have copy / paste capability.

.4 Upon initial power up of the VFD, the keypad shall display a start up guide that will sequence all the necessary parameter adjustments for general start up.

.5 Standard advanced programming and trouble-shooting functions shall be available by using a personal computer’s RS-232 port and Windows™ based software. In addition the software shall permit control and monitoring via the VFD’s RS232 port. The manufacturer shall supply a diskette with the required software. An easily understood instruction manual and software help screens shall also be provided. The computer software shall be used for modifying the drive setup and reviewing diagnostic and trend information as outlined in this section through section 18.

.6 The operator shall be able to scroll through the keypad menu to choose between the following:

.1 Parameter Menu

.2 Keypad Control

.3 System Menu

.4 Expander Boards

.5 Monitoring Menu

.6 Operate Menu

.7 The following setups and adjustments, at a minimum, are to be available:

.1 Start command from keypad, remote or communications port

.2 Speed command from keypad, remote or communications port

.3 Motor direction selection

.4 Maximum and minimum speed limits

.5 Acceleration and deceleration times, two settable ranges

.6 Critical (skip) frequency avoidance

.7 Torque limit

.8 Multiple attempt restart function

.9 Multiple preset speeds adjustment

.10 Catch a spinning motor start or normal start selection

.11 Programmable analog output

.15 The VFD shall have the following system interfaces:

.1 Inputs – A minimum of six (6) programmable digital inputs, two (2) analog inputs and serial communications interface shall be provided with the following available as a minimum:

.1 Remote manual/auto

.2 Remote start/stop

.3 Remote forward/reverse

.4 Remote preset speeds

.5 Remote external trip

.6 Remote fault reset

.7 Process control speed reference interface, 4-20mAdc

.8 Potentiometer or process control speed reference interface, 0 -10Vdc

.9 RS232 programming and operation interface port

.2 Outputs – A minimum of two (2) discrete programmable digital outputs, one (1) programmable open collector output, and one (1) programmable analog output shall be provided, with the following available at minimum.

.1 Programmable relay outputs with one (1) set of Form C contacts for each, selectable with the following available at minimum:

.1 Fault

.2 Run

.3 Ready

.4 Reversing

.5 Jogging

.6 At speed

.7 In torque limit

.8 Motor rotation direction opposite of commanded

.9 Overtemperature

.2 Programmable open collector output with available 24Vdc power supply and selectable with the following available at minimum:

.1 Fault

.2 Run

.3 Ready

.4 Reversing

.5 Jogging

.6 At speed

.7 In torque limit

.8 Motor rotation direction opposite of commanded

.9 Overtemperature

.3 Programmable analog output signal, selectable with the following available at minimum:

.1 Output frequency

.2 Frequency reference

.3 Motor speed

.4 Output current

.5 Motor torque

.6 Motor power

.7 Motor voltage

.8 DC link voltage

.9 PID controller reference value

.10 PID controller actual value 1

.11 PID controller actual value 2

.12 PID controller error value

.13 PID controller output

.3 Capability of two additional expandable I/O interface cards. Upon installation, software shall automatically identify the interface card and activate the appropriate parameters.

.16 Monitoring and Displays

.1 The VFD's display shall be a LCD type capable of displaying three (3) lines of text and the following thirteen (13) status indicators:

.1 Run

.2 Forward

.3 Reverse

.4 Stop

.5 Ready

.6 Alarm

.7 Fault

.8 I/O Terminal

.9 Keypad

.10 Bus/comm

.11 Hand

.12 Auto

.13 Off

.2 The VFD's keypad shall be capable of displaying the following monitoring functions at a minimum:

.1 Motor Speed (RPM and %)

.2 Frequency reference

.3 Output frequency

.4 Motor current

.5 Motor torque

.6 Motor power

.7 Motor voltage

.8 DC-link voltage

.9 Heatsink temperature

.10 Motor run time (resetable)

.11 Total operating days counter

.12 Operating hours (resetable)

.13 Total megawatt hours

.14 Megawatt hours (resetable)

.15 Voltage level of analog input

.16 Current level of analog input

.17 Digital inputs status

.18 Digital and relay outputs status

.19 Motor temperature rise

.20 PID references

.17 Protective Functions

.1 The VFD shall include the following protective features at minimum:

.1 Overcurrent

.2 Overvoltage

.3 System fault

.4 Undervoltage

.5 Input line supervision

.6 Output phase supervision

.7 Undertemperature

.8 Overtemperature

.9 Motor stalled

.10 Motor overtemperature

.11 Motor underload

.12 Logic voltage failure

.13 Microprocessor failure

.14 Brake chopper supervision

.15 DC Injection braking

.2 The VFD shall provide ground fault protection during power-up, starting, and running. VFD's with no ground fault protection during running are not accepted.

.18 Diagnostic Features

.1 Active Faults

.1 The last 10 faults shall be recorded and stored in sequential order

.2 Fault code and description of fault shall be displayed on the keypad.

.3 Fault or alarm LED shall blink

.4 Display drive data at time of fault

.5 In the event several faults occur simultaneously, the sequence of active faults shall be viewable.

.2 Fault History

.1 The last 30 faults shall be recorded and stored in sequential order.

.2 Display drive data at time of fault

.19 Additional features included in the VFD

.1 A HMCP or MMP device shall provide a disconnect means with provision for lockout. Disconnect handles mounted on the door will not be accepted. The handle position shall indicate ON and OFF condition. Operator shall be interlocked with cover to prevent opening with disconnect in the ON position.

.2 The following indicating lights shall be provided on the keypad.

.1 Drive/Bypass Ready (Flashing in Bypass Mode)

.2 Drive/Bypass Run

.3 Drive Fault

.3 The current withstand rating of the drive shall be 100,000 AIC. The bypass shall have an interrupting capacity of 65,000 AIC or greater. The combined withstand rating of drive and bypass must be 65,000 AIC or higher.

.4 The VFD shall have a cooling fan that is field replaceable using non-screw accessibility.

.20 Enclosure

.1 The VFD and bypass shall be designed in a NEMA Type 1 enclosure to provide enhanced protection against radiated EMI/RFI.

.2 The VFD shall have complete front accessibility with easily removable assemblies.

.3 Cable entry shall be top or bottom entry.

.21 Acceptable Manufacturers

.1 Eaton/Cutler Hammer (Johnson Controls)

.2 ABB

.2 Local Control Panels

.1 All control panels shall be factory constructed, incorporating the BMS 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 perforated sub-panel, hinged door, and slotted flush latch.

.2 In general, the control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, 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. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.

.3 All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.

.4 Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.

.5 All wiring shall be neatly installed in plastic trays or tie-wrapped.

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

.3 Power Supplies

.1 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.

.2 Input: 120 VAC +10%, 60Hz.

.3 Output: 24 VDC.

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

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

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

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

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

.4 Thermostats

.1 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.

.5 Speed Controller

.1 Single Phase Fan Speed control for EF-1, shall be controlled by Johnson Controls S66 Electronic Fan Speed Controller.

3. PERFORMANCE/EXECUTION

3.1 BMS Specific Requirements

.1 Graphic Displays

.1 Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.

.2 User shall access the various system schematics via a graphical penetration scheme and/or menu selection. .

.2 Custom Reports:

.1 Provide custom reports as required for this project:

.3 Actuation / Control Type

.1 Primary Equipment

.1 Controls shall be provided by equipment manufacturer as specified herein.

.2 All damper and valve actuation shall be electric.

.2 Air Handling Equipment

.1 All air handers shall be controlled with a HVAC-DDC Controller

.2 All damper and valve actuation shall be electric.

.3 Terminal Equipment:

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

.2 All Terminal Units shall be controlled with HVAC-DDC Controller)

3.2 Installation Practices

.1 BMS Wiring

.1 All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BMS Contractor unless specifically shown on the Electrical Drawings under Division 26 Electrical. All wiring shall comply with the requirements of applicable portions of Division 26 and all local and national electric codes, unless specified otherwise in this section.

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

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

.4 Class 2 Wiring

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

.2 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.

.5 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.

.6 Provide for complete grounding of all applicable 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.

.2 BMS Line Voltage Power Source

.1 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided by Division 26.

.2 Circuits used for the BMS shall be dedicated to the BMS and shall not be used for any other purposes.

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

.3 BMS Raceway

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

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

.3 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.

.4 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.

.4 Penetrations

.1 Provide fire stopping for all penetrations used by dedicated BMS conduits and raceways.

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

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

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

.5 BMS Identification Standards

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

.2 Cable types specified in Item A shall be color coded for easy identification and troubleshooting.

.6 BMS Panel Installation

.1 The BMS 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.

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

.7 Input Devices

.1 All Input devices shall be installed per the manufacturer recommendation

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

.8 HVAC Input Devices – Genera1

.1 All Input devices shall be installed per the manufacturer recommendation

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

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

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

.5 Outside Air Sensors

.1 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.

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

.6 Water Differential Pressure Sensors

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

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

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

.7 Medium to High Differential Water Pressure Applications (Over 21” w.c.):

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

.8 Building Differential Air Pressure Applications (-1” to +1” w.c.):

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

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

.9 Air Flow Measuring Stations:

.1 Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct.

.2 Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.

.10 Duct Temperature Sensors:

.1 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.

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

.3 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.

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

.11 Space Sensors:

.1 Shall be mounted per ADA requirements.

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

.12 Low Temperature Limit Switches:

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

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

.3 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.

.13 Air Differential Pressure Status Switches:

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

.14 Water Differential Pressure Status Switches:

.1 Install with shut off valves for isolation.

.9 HVAC Output Devices

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

.2 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.

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

.4 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.

.5 Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building 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

3.3 Commissioning

.1 Fully commission all aspects of the Building Management System work.

.2 Acceptance Check Sheet

.1 Prepare a check sheet that includes all points for all functions of the BMS as indicated on the point list included in this specification.

.2 Submit the check sheet to the Contract Administrator for approval.

.3 The Contract Administrator will use the check sheet as the basis for acceptance with the BMS Contractor.

.3 Promptly rectify all listed deficiencies and submit to the Contract Administrator that this has been done.

END OF SECTION