ADDENDUM #1

October 8, 2012

Re: Harrisburg Area Community College
Gettysburg Campus HVAC RTU #1 Replacement,
Solicitation # RFB13-09

From: Eastern PCM, LLC
Construction Manager – HACC
645 N. 12th Street, Suite 200
Lemoyne, PA 17043

To: All Planholders

This Addendum is hereby made part of the Plans and Project Manual dated September 26, 2012 for the above referenced project. The provisions of this Addendum are intended to supplement the provisions of the Plans and Project Manual and/or supersede them where contradictory thereto.

This Addendum contains changes to the requirements of the Plans and Project Manual. Such changes shall be incorporated into the Plans and Project Manual and shall apply to work with the same meaning and force as if they had been included in the original Plans and Project Manual. Where this Addendum modifies a portion of a paragraph or phrase of the Project Manual, the remaining unmodified portion of the paragraph or phrase shall remain in force.

The conditions and terms of the Plans and Project Manual shall govern work described in this Addendum. Whenever the conditions of work, or the quality or quantity of materials or workmanship are not fully described in this Addendum, the conditions of work etc. included in the Plans and Project Manual for similar items of work shall apply to the work described in this Addendum. If no similar items of work are included in the Plans and Project Manual, the quality of material and workmanship shall be subject to the written acceptance of the Architect.

1.1 PRE-BID MEETING MINUTES

Meeting minutes from the Pre-Bid Meeting held on October 3, 2012 are attached and are a part of this Addendum. In the event of a conflict between the information contained in the Pre-Bid Meeting Notes and the Drawings, Specifications and responses to questions contained in this Addendum, the latter shall take precedence.

1.2 CHANGES TO THE PROJECT MANUAL

A. Section 00010 – Table of Contents

ADD Section 230900 – ATC SYSTEMS to the Table of Contents.

B. Section 00150 – Information to Bidders

Article 5 – Completion Schedule and Work Hours

REVISE section A. Schedule to read:

i. Contract Award*:	November 7, 2012
ii. Notice to Proceed**:	November 15, 2012
iii. On-Site Construction:	March 8 – March 17, 2013
iv. Substantial Completion:	April 15, 2013

* Contract award is subject to approval of HACC's Board of Trustees on November 6, 2012.

** Shop drawings, submittals, equipment ordering, etc.

REVISE section B. Working Hours to read:

i. All work during the week of March 8 – March 17, 2013 is at Contractor's discretion.

ii. Work outside of March 8 – March 17, 2013 must be coordinated with the Owner and may be required to be performed at night, 10:00PM – 7:00AM.

C. Section 230855 – Air Handling Units

1. **DELETE** paragraph 2.1.M.1 Single Packaged Controller in its entirety and **REPLACE** with the following:

    1. "Rooftop unit shall be equipped with VFD Controls."

2. **DELETE** Paragraph 2.2 – Changeover/Bypass System in its entirety and **REPLACE** with the following:

2.2 NON FAN POWERED VAV BOXES

A. Manufacturers:

1. Basis of Design: Johnson Controls
2. Accepted Substitutes:
    a. Warren
    b. ETI
    c. Trane

B. VAV Boxes shall be single-duct terminal units.

C. Casing: 22-gauge galvanized steel.

D. Agency Listing: The unit is UL and Canadian UL listed as a room air terminal unit. ARI 880 listed.

E. Insulation: 1" foil faced insulation. Interior surface of the unit casing is acoustically and thermally lined with 1", 2.0 lb/cuft density glass fiber with foil facing. The insulation R-Value is 4.3. The insulation is UL listed and meets NFPA-90A and UL 181 Standards as well as Bacteriological Standard ASTM C665.

F. Primary Air Valve: Cylindrical flow control device with integral electric actuator. Valve inlet is die cast aluminum and tapered to fit standard round flexible ductwork. Maximum leak rate is 1% at 4" wg inlet static pressure. Integral multiple point, averaging flow sensing ring is provided for primary airflow measurement within +/- 5% of unit nominal airflow with 1-1/2 diameters of straight duct upstream of the unit. Integral flow taps and a calibration chart are provided on each unit.

G. Outlet Connection: Flanged Connection – A rectangular opening on the unit discharge to accept a 90° flanged ductwork connection.

H. Provide with the following:

1. Access panel is provided and centered in the bottom of the unit for access to the primary air valve.
2. Low voltage with all wiring by the ATC Installer.

I. Transformer: The 50 VA transformer is factory mounted in the fan control box to provide 24 VAC for controls.

D. Section 230900 – ATC Systems

ADD this section, attached.

E. Section 283110 – Expansion of the Existing Fire Alarm System

ADD the following to Paragraph 2.1.A:

Contact: Berkshire Systems Group, Jeff Neiderer, Phone: (610) 775-1200.

1.3 CHANGES TO THE DRAWINGS

A. **ADD** the following sketch, attached: ADM-1: Mechanical Revisions to Drawing ME2.0.

B. Drawing ME1.0 – Partial Mechanical/Electrical Demolition Floor Plan

REVISE as follows:

1. Remove existing bypass damper and associated ductwork associated with removed RTU-1.
2. All zone dampers shown as existing to remain shall have the zone box controller replaced with a new controller.

C. Drawing ME2.0 – Partial Mechanical/Electrical Floor Plan

REVISE as follows:

1. All zone dampers shown as existing to remain shall have the zone box controller replaced with a new controller.
2. All new zone dampers shall be VAV boxes instead of zone dampers.
3. General revisions to Drawing ME2.0, refer to Sketch ADM-1.

Attached:

1. Pre-Bid Meeting Minutes dated October 3, 2012
2. Section 230900 – ATC Systems
3. Sketch ADM-1 dated October 5, 2012

END OF ADDENDUM

Please sign and return this page, via fax, to Eastern PCM, LLC at (717) 233-1666 indicating receipt of this Addendum.

Gettysburg Campus HVAC RTU #1 Replacement
RFB13-09

Addendum #_____ has been received.

Company: _____
Print Company Name

Received By: _____
Print Name Signature

Date: _____

Please check one:

_____ We are bidding as a prime contractor
_____ We are not bidding
_____ We are a sub-contractor

EASTERN PCM, LLC

HACC
Gettysburg Campus
HVAC RTU #1 Replacement

Pre-Bid Meeting

October 3, 2012
9:00 AM

Meeting Minutes

Attendees

Ron Cline – Harrisburg Area Community College
Brian Miller – Harrisburg Area Community College
Michael Hunt – Moore Engineering
Greg Lamay – Eastern PCM, LLC
David Barth – Thermotech, LLC
Justin Horst – McClure Company
Barry Mongold – H & R Mechanical
John Ziegler – Midstate Mechanical and Electrical
Rodger Ilgenfritz – SSM Industries, Inc.
Josh Lawrence – Swam Electric Company, Inc.
Terry Steely – Enginuity, LLC
Chris Croman – Enginuity, LLC

1.0 Mr. Lamay welcomed all attendees.

1.1 Introduction of Team

a)	Owner	**HACC, Harrisburg Area Community College**	
		Ron Cline	Facilities Director
		Brian Miller	Facilities Supervisor
		Garry Crider	Purchasing Manager
b)	Engineer	**Moore Engineering**	
		Michael Hunt	Project Engineer
c)	Construction Manager	**Eastern PCM, LLC**	
		Greg Lamay	Project Manager

1.2 Drawings were prepared by Moore Engineering, dated September 21, 2012. The Project Manual is dated September 26, 2012.

1.3 Bid submission requirements were discussed including Bid Form, Bid Security, the Non Collusion Affidavit and the MBE/WBE utilization forms which are all available in the Project Manual.

1.4 The bidders were informed that the project will be subject to Prevailing Wages. Wages are included in the Project Manual.

1.5 The following bid scheduled was presented:

Bid Date:	October 11, 2012 at 2:00 PM at 349 Wiconisco Street, Harrisburg PA, 17110 Room 223. Public opening to follow in Room 224.
Contract Award:	November 7, 2012. This date is based on HACC Board of Trustees approval at the November 6, 2012 meeting.

Construction Start:	November 15, 2012 (Submittals, Shop Drawings, etc.)
On Site Construction:	Spring Break; dates will be published in an Addendum.
Substantial Completion:	April 15, 2013

1.6 The Scope was presented as follows:
The work will be performed under a Single Prime Contract and consists of the replacement of the existing 15-ton rooftop HVAC unit with two (2) separate units: (1) 7.5-ton and (1) 10-ton, gas-fired rooftop unit. The work will include ductwork demolition, reconfiguration, and new installation to accommodate new units. New controls will be required, as well as modifications to existing controls. New electrical circuits will be required, and a new curb will be installed on the roof.

1.7 All questions are to be directed to Greg Lamay in the office of the Construction Manager in writing via fax or e-mail: Fax (717) 233-1666, E-mail: epcm@easternpcm.com. The last day for questions is October 5, 2012 at 4:00 PM.

1.8 A building permit is not expected to be required; trade specific permits are to be obtained by the respective Contractor.

1.9 The Contractors will be permitted to use the campus restroom facilities.

1.10 A designated area will be provided for contractor staging and material storage on site.

1.11 The Owner will designate parking for contractors.

1.12 All work is to be performed between 7:00AM and 5:00PM, Monday through Friday, during the week of Spring Break. Work performed outside of those hours will require approval of the Owner and Construction Manager. It was noted that the contract work not complete during that week, may need to be performed at night.

Respectfully Submitted,
Greg Lamay, Eastern PCM, LLC

The above summations are the interpretation of the author as to the items discussed and the decisions reached. Corrections or additions to these minutes are to be made in writing and sent to the attention of the Author no later than 5 days after receipt; otherwise, these minutes will stand as written.

cc: All Attendees

SECTION 230900 – ATC SYSTEMS

PART 1 - GENERAL

1.1 GENERAL

A. The general project scope to provide controls and instrumentation for the HVAC systems
   1. All systems are to be an extension of the existing HACC BMS network.
   2. All control dampers to be provided by the BMS contractor, with the actuators furnished, installed and wired by the BMS contractor.
   3. The variable frequency drives not provided as part of mechanical equipment are to be provided by BMS contractor as indicated on the drawings. The drives are to be provided with communication interface compatible with the BMS contractor system.
   4. Provide web based graphical displays of all primary and secondary equipment as well as building floor plans showing equipment locations and space condition information.

B. The following is the scope of work for this contractor. With regards to the sequences of operation, the BMS contractor shall:
   1. Provide extension of Building Level DDC control system integrated to existing BMS server
   2. Provide DDC controls, instrumentation for Air Handling Units, quantity to be obtained from schedule on drawings
   3. Provide controls for VAV boxes and existing Zone Dampers

1.2 RELATED DOCUMENTS

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

B. The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference the Division 15 Sections for details.

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

D. 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.

1.3 BMS DESCRIPTION

A. The Building Management System (BMS) shall be a complete system designed for use with the enterprise IT systems. 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 owner's IT staff to ensure that the FMS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN.

B. Provide open communications system. The system shall be an open architecture with the capabilities to support a multi-vendor environment. To accomplish this effectively, system shall be capable of utilizing standard protocols as follows as well as be able to integrate third-party systems via existing vendor protocols. System shall communicate via BACnet protocol according to ASHRAE standard 135. The system shall not be limited to only use open communication protocols, but also be able to integrate a wide variety of third-party devices and applications via existing vendor protocols and through the latest software standards.

C. 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.

1.4 QUALITY ASSURANCE

A. General:
1. The Building Management System Contractor shall be the primary manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Building Management Systems.
2. The BMS Contractor shall be a recognized national manufacturer, installer and service provider of BMS.
3. No dealers, franchises or other suppliers other that factory owned branch offices of the controls manufacture shall be considered for execution of this project.
4. The BMS Contractor shall have a branch facility within a 100-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis.

1.5 SUBMITTALS

A. Shop Drawings, Product Data, and Samples:
1. The BMS contractor shall submit a list of all shop drawings with submittals dates within 60 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 Architect and Engineer for Contract compliance.
3. Allow 15 working days for the review of each package by the Architect and Engineer 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 Owner.
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:
   a. BMS network architecture diagrams including all nodes and interconnections.
   b. Systems schematics, sequences and flow diagrams.
   c. Points schedule for each point in the BMS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.
   d. Samples of Graphic Display screen types and associated menus.
   e. Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
   f. 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.
   g. 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.
   h. Room Schedule including a separate line for each VAV box and/or terminal unit indicating location and address
   i. Details of all BMS interfaces and connections to the work of other trades.
   j. Product data sheets or marked catalog pages including part number, photo and description for all products including software.

1.6 RECORD DOCUMENTATION

A. Operation and Maintenance Manuals:
   1. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner'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:
      a. Table of contents.
      b. 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.
      c. Manufacturers product data sheets or catalog pages for all products including software.
      d. System Operator’s manuals.
      e. Archive copy of all site-specific databases and sequences.
      f. BMS network diagrams.
      g. 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.

1.7 WARRANTY

A. Standard Material and Labor Warranty:

1. Provide a one-year labor and material warranty on the BMS.
2. 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 BMS Contractor at the cost of the BMS Contractor.
3. 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 BMS Contractor's normal business hours.

PART 2 - PRODUCTS

2.1

A. General Requirements: All products listed in this section shall be provided as required to meet the intent of the project design and sequences of operation

B. 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 owner provided networks.

C. 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.

D. 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.

E. Systems shall utilize wireless communication where applicable for temperature sensing and field controller communication

F. Acceptable BMS Manufacturers:
   1. Johnson Controls, Metasys
   2. No substitutions

G. Acceptable Installing Contractors
   1. Johnson Controls Branch Office,
      196 Limekiln Rd,
      New Cumberland Pa
      Contact Scott Schmittel
      717-712-1804
   2. No substitutions

2.2 BMS ARCHITECTURE

A. 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. DDC Controllers shall communicate on the automation network via BACnet TCP/IP protocol over Ethernet
3. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
4. 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.

B. Control Network:
1. Network Automation Engines shall provide supervisory control over the control network and shall have the capability to simultaneously support all three (3) of the following communication protocols:
   a. BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.
   b. LonWorks enabled devices using the Free Topology Transceiver (FTT-10a).
   c. 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 Application Specific Controllers shall reside on the control network.
4. Control network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135.
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.

2.3 USER INTERFACE

A. Alarms:
1. Alarms shall be routed directly from Network Automation Engines to PCs and servers. It shall be possible for specific alarms from specific points to be routed to specific PCs and servers. The alarm management portion of the user interface shall, at the minimum, provide the following functions:
   a. Log date and time of alarm occurrence.
   b. Generate a “Pop-Up” window, with audible alarm, informing a user that an alarm has been received.
   c. Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.
   d. 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.

e. Provide the ability to direct alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop up window described above. Systems that use e-mail and pagers as the exclusive means of annunciating alarms are not acceptable.
f. Any attribute of any object in the system may be designated to report an alarm.

B. Schedules:
1. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:
a. Weekly schedules
b. Exception Schedules
c. Monthly calendars.
2. Weekly schedules shall be provided for each group of equipment with a specific time use schedule.

C. Password:
1. Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, based on an assigned password.
2. Each user shall have the following: a user name (24 characters minimum), a password (12 characters minimum), and access levels.
3. The system shall allow each user to change his or her password at will.

D. Screen Manager - The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.

E. Dynamic Color Graphics:
1. The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.
2. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.
3. The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.
4. Graphics runtime functions – A maximum of 16 graphic applications shall be able to execute at any one time on a user interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:
a. All graphics shall be fully scalable
b. The graphics shall support a maintained aspect ratio.
c. Multiple fonts shall be supported.
d. Unique background shall be assignable on a per graphic basis.
e. The color of all animations and values on displays shall indicate if the status of the object attribute.
5. Operation from graphics – It shall be possible to change values (setpoints) and states in system controlled equipment by using drop-down windows accessible via the pointing device

6. Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations, and defining all runtime binding.
    a. The graphic editing tool shall in general provide for the creation and positioning of point objects by dragging from tool bars or drop-downs and positioning where required.
    b. In addition, the graphic editing tool shall be able to add additional content to any graphic by importing backgrounds in the SVG, BMP or JPG file formats.
7. Aliasing – Many graphic displays representing part of a building and various building components are exact duplicates, with the exception that the various variables are bound to different field values. Consequently, it shall be possible to bind the value of a graphic display to aliases, as opposed to the physical field tags.

F. Historical trending and data collection:
1. Each Automation Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:
    a. Any point, physical or calculated, may be designated for trending. Three methods of collection shall be allowed:
        1) Defined time interval
        2) Upon a change of value
    b. Each Automation Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.

G. Trend data viewing and analysis:
1. Provide a trend viewing utility that shall have access to all database points.
2. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.
3. The trend viewing utility shall have the capability to define trend study displays to include multiple trends
4. Displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.
5. Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. This is a zoom capability.
6. Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed.
7. Trend studies shall be capable of calculating and displaying calculated variables including highest value, lowest value and time based accumulation.

2.4 BUILDING LEVEL CONTROLLER

A. BACnet Building Controller (BBC):
1. The BACnet Building Controller **(BBC**) shall be a fully user-programmable, supervisory controller. The **(BBC**) shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other BACnet building controllers.

2. Automation network – The **(BBC**) shall reside on the automation network and shall support a subnet of system controllers.
3. User Interface – Each **(BBC**) 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.
    a. The web based UI software shall be imbedded in the **(BBC**). Systems that require a local copy of the system database on the user's personal computer are not acceptable.
    b. The **(BBC**) shall support a minimum of two (2) concurrent users.
    c. The web based user shall have the capability to access all system data through one **(BBC**).
    d. The **(BBC**) shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the **(BBC**).
4. Controller network – The **(BBC**) shall support the following communication protocols on the controller network:
    a. The **(BBC**) 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 **(BBC**)shall support a minimum of 50 control devices.
    b. The **(BBC**)shall support LonWorks enabled devices using the Free Topology Transceiver FTT10.
        1) All LonWorks controls devices shall be LonMark certified.
        2) The **(BBC**)shall support a minimum of 64 LonWorks enabled control devices.
    c. The **(BBC**)shall support the Johnson Controls N2 Field Bus.
        1) The **(BBC**)shall support a minimum of 50 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 **(BBC**).
    d. Wireless applications for the Controls network shall be permitted where applicable.

2.5 DDC SYSTEM CONTROLLERS

A. General Requirements: DDC controllers shall be provided as required to meet the intent of the project design and sequences of operation.

B. Field Equipment Controller (FEC):
1. The Field Equipment Controller (FEC) shall be a fully user-programmable, digital controller that communicates via BACnet MS/TP protocol.
2. The FEC shall employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.

3. Controllers shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.

C. VAV Terminal Unit Controller (VMA):
1. The VMA shall provide both standalone and networked direct digital control of pressure-independent, variable air volume terminal units.
2. 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.
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 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.
5. Each VMA shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.
6. The VMA shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.
7. 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.
8. 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.
9. 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.
10. The VMA firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.
11. The VMA shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.
12. 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.
13. 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.
    a. Absolute temperature loop error.
    b. Signed temperature loop error.
    c. Absolute airflow loop error.

d. Signed airflow loop error.
e. Average damper actuator duty cycle.

14. The VMA shall detect system error conditions to assist in managing the VAV zones. The error conditions shall consist of:
    a. Unreliable space temperature sensor.
    b. Unreliable differential pressure sensor.
    c. Starved box.
    d. Insufficient cooling.
    e. Insufficient heating.
15. 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.
16. 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.
17. 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.”
18. Inputs:
    a. Analog inputs shall monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:
        1) 0-10 VDC Sensors
        2) 1000ohm RTDs
        3) NTC Thermistors
    b. Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input “bouncing.”
    c. For noise immunity, the inputs shall be internally isolated from power, communications, and output circuits.
19. Outputs:
    a. Analog outputs shall provide the following control outputs:
        1) 0-10 VDC
    b. Binary outputs shall provide a SPST Triac output rated for 500mA at 24 VAC.
    c. For noise immunity, the outputs shall be internally isolated from power, communications, and other output circuits.

2.6 FIELD DEVICES

A. Input/Output Module:
1. The Input/Output Module provides additional inputs and outputs for use in the FEC.
2. The IOM shall communicate with the FEC using BACnet Standard protocol SSPC-135, Clause 9.

B. Networked Thermostat:
1. The Networked Thermostat shall be capable of controlling unitary HVAC system such as fan coil units, rooftop units, unit heaters, and variable volume zoning systems.

2. The Networked Thermostat shall communicate using BACnet Standard protocol SSPC-135, Clause 9.
    a. The Networked Thermostat shall support remote read/write and parameter adjustment from the web based User Interfaceable through a Network Automation Engine.

C. Network Sensors:
1. The Network Sensors shall have the ability to monitor the following variables as required by the systems sequence of operations:
    a. Zone Temperature
    b. Zone humidity
    c. Zone setpoint
2. The NS shall transmit the zone information back to the controller using BACnet Standard protocol SSPC-135, Clause 9.
3. The Network Sensors shall include the following items:
    a. A backlit Liquid Crystal Display (LCD) to indicate the Temperature, Humidity and Setpoint.
    b. An LED to indicate the status of the Override feature.
    c. A button to toggle the temperature display between Fahrenheit and Celsius.
    d. A button to initiate a timed override command

D. Many-To-One Wireless Room Temperature Sensor System:
1. The Many-To-One System Receiver (WRS Receiver) shall receive wireless Radio Frequency (RF) signals containing temperature data from multiple Wireless Room Temperature Sensors (WRS Sensors).
2. The WRS Receiver shall be capable of communication with WRS Sensors up to a distance of 200 Feet.
3. The WRS Sensors shall sense and report room temperatures to the WRS Receiver.
    a. The WRS sensors shall be available with
        1) Warmer/Cooler Set Point Adjustment
        2) No Set Point Adjustment
        3) Set Point Adjustment Scale – 55 to 85º F.
    b. The WRS sensors shall be assembled in NEMA 1 plastic housings.

2.7 INPUT DEVICES

A. General Requirements:
1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.
2. All input device references to be understood as to be “where required to meet the intent of the sequences of operation”

B. Temperature Sensors:
1. General Requirements:
    a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
    b. 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.

c. 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	± .5°F.
Room Temp	± .5°F.
Duct Temperature	± .5°F.
All Others	± .75°F.

2. Room Temperature Sensors:
   a. Room sensors shall be constructed for either surface or wall box mounting.
   b. Room sensors shall have the following options when specified on the project plans:
      1) Setpoint reset slide switch providing a ±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:
   a. Room sensors shall be constructed for either surface or wall box mounting.
   b. 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. Room Temperature and Humidity Sensors with Integral Display:
   a. Room sensors shall be constructed for either surface or wall box mounting.
   b. 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 room humidity
      3) Display and adjust room comfort setpoint.
      4) Display and adjust fan operation status.
      5) Timed override request push button with LED status for activation of after-hours operation.
      6) Display controller mode.
      7) Password selectable adjustment of setpoint and override modes.
5. Thermo wells:
   a. When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.
   b. Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.
   c. 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.

d. Thermo wells shall be constructed of 316 stainless steel or brass as directed by the project plans.

6. Outside Air Sensors:
   a. 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.
   b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
   c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
7. Duct Mount Sensors:
   a. 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.
   b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
   c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
8. Averaging Sensors:
   a. 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.
   b. 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.
   c. Capillary supports at the sides of the duct shall be provided to support the sensing string.
9. Acceptable Manufacturers: Johnson Controls, Setra.

C. 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.

D. Differential Pressure Transmitters:
1. General Air and Water Pressure Transmitter Requirements:

a. 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.
b. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.
c. 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.
d. 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.):
   a. 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.
   b. 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.
   c. Acceptable Manufacturers: Setra and Mamac.
3. Medium to High Differential Water Pressure Applications (Over 21" w.c.):
   a. 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).
   b. 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.
   c. Acceptable Manufacturers: Setra and Mamac.
4. Building Differential Air Pressure Applications (-1" to +1" w.c.):
   a. 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.
   b. 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.
   c. Acceptable Manufacturers: Johnson Controls and Setra.
5. Low Differential Air Pressure Applications (0" to 5" w.c.):

a. 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.
b. 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.
c. Acceptable Manufacturers: Johnson Controls and Setra.

6. Medium Differential Air Pressure Applications (5" to 21" w.c.):
   a. 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.).
   b. 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.
   c. Acceptable manufacturers: Johnson Controls and Setra.

E. Flow Monitoring:
   1. Air Flow Monitoring shall be a thermal dispersion or multi-point, self-averaging pitot traverse station with integral air straightener-equalizer honeycomb cell, capable of continuously measuring fan discharges or ducted airflow with a certified accuracy of 2% or better when tested according to AMCA 610.
      a. Fan Inlet Air Flow Measuring Stations
         1) Airflow measuring stations shall be manufactured by Air Monitor Corp., Tek-Air Systems, Inc., Ebtron, or Dietrich Standard.
      b. Duct Air Flow Measuring Stations:
         1) Acceptable manufacturers: Air Monitor Corp., Tek-Air, Ebtron, and Dietrich Standard.
   2. Water Flow Monitoring:
      a. Water flow meters shall be electromagnetic type with integral microprocessor-Based electronics. The meter shall have an accuracy of 0.25%.
      b. Acceptable manufacturers: Johnson Controls, Onicon or equal

F. Power Monitoring Devices:
   1. Current Measurement (Amps):
      a. Current measurement shall be by a combination current transformer and a current transducer. The current transformer shall be sized to reduce the full

amperage of the monitored circuit to a maximum 5 Amp signal, which will be converted to a 4-20 mA DDC compatible signal for use by the Facility

b. Acceptable manufacturers: Veris Industries

G. Smoke Detectors: Ionization type air duct detectors shall be furnished as specified elsewhere in Division 16 for installation under Division 15. All wiring for air duct detectors shall be provided under Division 16, Fire Alarm System.

H. Status and Safety Switches:

1. General Requirements: 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:
   a. 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.
   b. Acceptable manufacturers: Veris Industries
3. Air Filter Status Switches:
   a. 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.
   b. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.
   c. Acceptable manufacturers: Johnson Controls, Cleveland Controls
4. Air Flow Switches:
   a. 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.
   b. Acceptable manufacturers: Johnson Controls, Cleveland Controls
5. Air Pressure Safety Switches:
   a. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.
   b. Acceptable manufacturers: Johnson Controls, Cleveland Controls
6. Water Flow Switches:
   a. Water flow switches shall be equal to the Johnson Controls P74.
7. Low Temperature Limit Switches:
   a. 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.
   b. 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.
   c. 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.
   d. The low temperature limit switch shall be equal to Johnson Controls A70.

2.8 OUTPUT DEVICES

A. Actuators:
1. General Requirements:
   a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque. All damper and valve actuators that control in more than 2 positions (open/closed) shall be fully modulating
   b. Damper and valve actuators shall be electronic as specified in the System Description section.
2. All output device references to be understood as to be “where required to meet the intent of the sequences of operation”
3. Electronic Damper Actuators:
   a. Electronic damper actuators shall be direct shaft mount.
   b. Modulating and two-position actuators shall be provided as required by the sequence of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.
   c. Acceptable manufacturers: Johnson Controls, Belimo.
4. Electronic Valve Actuators:
   a. Electronic valve actuators shall be manufactured by the valve manufacturer.
   b. Modulating and two-position actuators shall be provided as required by the sequence of operations.
   c. Acceptable manufacturers: Johnson Controls, Valve Solutions

B. 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.

C. Control Relays:
   1. Control Pilot Relays:
      a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
      b. Mounting Bases shall be snap-mount.
      c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
      d. Contacts shall be rated for 10 amps at 120VAC.
      e. Relays shall have an integral indicator light and check button.
      f. Acceptable manufacturers: Johnson Controls, Lectro

D. 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) shall be sized for a minimum 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

2.9 MISCELLANEOUS DEVICES

A. Adjustable Frequency Drive (AFD):

1. Where shown on the drawings, adjustable frequency drives 1 through 75 HP shall have the following features:
2. The AFDs shall be rated for 480 Vac (optional input voltages of 208, 240 Vac through 30 HP). The AFD 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.
3. The AFDs 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 AFDs 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 AFD shall run at the above listed switching frequencies.
4. The AFDs shall have an efficiency at full load and speed that exceeds 95% for AFDs below 15 HP and 97% for drives 15 HP and above. The efficiency shall exceed 90% at 50% speed and load.
5. The AFDs shall maintain a minimum line side displacement power factor of 0.96, regardless of speed and load.
6. The AFDs shall have a one (1) minute overload current rating of 110% for variable torque applications.
7. The AFDs 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 AFD.
8. The AFDs shall have an integral EMI/RFI filter as standard.
9. The AFDs 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.
10. 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.
11. 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 AFD supplier three (3) weeks prior to requiring harmonic calculations.
12. The system containing the AFDs 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 AFDs provided with the standard input line reactor or optional input isolation transformer, the AFD 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.

PART 3 - PERFORMANCE/EXECUTION

3.1 BMS SPECIFIC REQUIREMENTS

A. Graphic Displays:
   1. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list.
   2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection. .

B. Actuation / Control Type:
   1. Primary Equipment:
      a. Controls shall be provided by equipment manufacturer as specified herein.
      b. All damper and valve actuation shall be electric.
   2. Air Handling Equipment:
      a. All air handers shall be controlled with a HVAC-DDC Controller
      b. All damper and valve actuation shall be electric.
   3. Terminal Equipment:
      a. Terminal Units (VAV, UV, etc.) shall have electric damper and valve actuation.
      b. All Terminal Units shall be controlled with HVAC-DDC Controller)

3.2 INSTALLATION PRACTICES

A. 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 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.
   2. Class 2 Wiring:
      a. Class 2 wiring for sensors, actuators and communication buses shall be in conduit where exposed or inaccessible.
      b. Class 2 wiring for sensors, actuators and communication buses shall be run using “open cable” wiring practices where concealed yet accessible. Open cable to be plenum rated where required.
   3. 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.

B. 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 16.
   2. Circuits used for the BMS shall be dedicated to the BMS and shall not be used for any other purposes.

C. 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:
    a. 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.
    b. Sensors shall be installed with a rain proof, perforated cover.
6. Water Differential Pressure Sensors:
    a. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.
    b. Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
    c. The transmitters shall be installed in an accessible location wherever possible.
7. Medium to High Differential Water Pressure Applications (Over 21” w.c.):
    a. Air bleed units, bypass valves and compression fittings shall be provided.
8. Building Differential Air Pressure Applications (-1” to +1” w.c.):
    a. Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
    b. The interior tip shall be inconspicuous and located as shown on the drawings.
9. Duct Temperature Sensors:
    a. 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.
    b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
    c. 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.
10. Space Sensors:
    a. Shall be mounted per ADA requirements.
    b. Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.
11. Low Temperature Limit Switches:
    a. Install on the discharge side of the first water or steam coil in the air stream.
    b. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.
    c. 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.
12. Air Differential Pressure Status Switches: Install with static pressure tips, tubing, fittings, and air filter.
13. Water Differential Pressure Status Switches: Install with shut off valves for isolation.

D. 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 TRAINING

A. The BMS contractor shall provide the following training services: One day of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BMS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

3.4 PROGRAMMING

A. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25% of available memory free for future use.

B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index.

C. Software Programming: Provide programming for the system as per specifications and adhere to the strategy algorithms provided. All other system programming necessary for the operation of the system but not specified in this document shall also be provided by the BAS vendor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequence of operations.

D. Operators' Interface: The controls manufacturer shall provide all the labor necessary to install, initialize, start-up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface data base, and any third party software installation and integration required for successful operation of the operator interface.

3.5 CLEANING

A. The Contractor shall clean up all debris resulting from his or her activities daily. The Contractor shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the General Contractor.

B. At the completion of work in any area, the Contractor shall clean all of his/her work, equipment, etc., making it free from dust, dirt and debris, etc.

C. At the completion of work, all equipment furnished under this Section shall be checked for paint damage, and any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.6 FIELD QUALITY CONTROL

A. Retain first paragraph below to require a factory-authorized service representative to perform, or assist Contractor with, field inspections, tests, and adjustments. Retain one of two options to suit Project; delete both to require only an inspection before field testing.

B. Perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning, and integrated system program commissioning. Document all commissioning information on commissioning data sheets that shall be submitted for record. Commissioning work that requires the shutdown of various systems or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the Department and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the Department and construction manager are present throughout the commissioning procedure.
   1. Prior to system program commissioning, verify that each control panel has been installed according to plans, specifications and approved shop drawings. Test, calibrate and bring on line each control sensor and device. Commissioning to include, but not be limited to:
   2. Sensor accuracy as confirmed at a single point by a calibrated test instrument.
   3. Sensor range.
   4. Verify analog limit and binary alarm reporting.
   5. Point value reporting.
   6. Binary alarm and switch settings.
   7. Actuator ranges.
   8. Fail safe operation on loss of control signal, electric power, network communications.
   9. The BAS vendor shall submit for record, as needed, all calibration certificates for testing instruments used in the commissioning process.
   10. Temperature: ¼ deg F or 1/2% full scale, whichever is less.
   11. Pressure: High Pressure (psi): ½ psi or 1/2% full scale, whichever is less.
   12. Low Pressure: 1/2% of full scale

13. Humidity: 2% RH
14. Electrical: 1/4% full scale

C. After control devices have been commissioned (i.e. calibrated, tested and signed off), each BAS program shall be put online and commissioned. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy. Any discrepancies between the specification and the actual performance will be immediately rectified and re-commissioned.

D. After all BAS programs have been commissioned; the BAS vendor shall verify the overall system performance as specified. Tests shall include, but not be limited to:
1. Data communication, both normal and failure modes.
2. Impact of component failures on system performance and system operation.
3. Season changeover.
4. Global application programs and point sharing.
5. System backup and reloading.
6. System status displays.
7. Diagnostic functions.
8. Power failure routines.
9. All commissioning documents listed below shall be submitted for record.
   a. Test data sheets, listing all programmed software points
   b. Sequence of operations verification sheets
   c. Calibration sheets for test equipment, as needed
10. After the above tests are complete and the system is demonstrated to be functioning as specified, the system shall be turned over to the Department.

3.7 TESTING AND DEMONSTRATION

A. The BAS vendor shall perform a complete test of the operator interface. Test duration shall be a minimum of 24 hours on-site. Tests shall be made in the presence of the Department or Department's representative and the Professional.

B. A complete demonstration and readout of the capabilities of the monitoring and control system shall be performed. The BAS vendor shall dedicate a minimum of 24 hours on-site with the Department and his representatives for a complete functional demonstration and training of all the system requirements, including operation, adjustment, and maintenance. The training sessions shall be in six 4-hour sessions. This demonstration constitutes a joint acceptance inspection, and permits acceptance of the delivered system for on-line operation. Refer to Division 01 Section "Demonstration and Training."

PART 4 - SEQUENCE OF OPERATION

4.1 ROOF TOP UNIT CONTROL SEQUENCE

A. Occupied mode: the occupied command, controlled via a network command, will index the system to occupied.

B. Unoccupied mode: while the system is in unoccupied mode the unit will cycle on when a zone controller's zone temperature drops below the unoccupied heating or cooling setpoint and the zone heating and cooling demand rises above zero percent.

C. Supply fan control: the variable speed supply fan will run continuously during occupied and cycle any time there is a call for heating or cooling during the unoccupied state.

D. Supply Fan VFD Control: the unit will control the VFD to maintain the discharge static setpoint as sensed by the discharge static pressure sensor.

E. Temperature control: the unit will stage on in sequence in sequence the heating or cooling based on the largest value between the average of the highest three zone heating demands and zone cooling demands. A zone weight setting will provide adjustment for each zone and there impact on the zone heating and cooling demand calculation.

4.2 ZONE DAMPER CONTROL SEQUENCE

A. Temperature control: the unit will control to maintain the zone temperature setpoint as sensed by the zone temperature sensor.

B. Heating\cooling mode: the roof top unit controller will determine the heating\cooling mode of the zone.

C. Occupied mode: the occupancy mode will be controlled via the roof top unit controller. The system may be temporarily placed in the occupied mode by a button on the zone sensor.

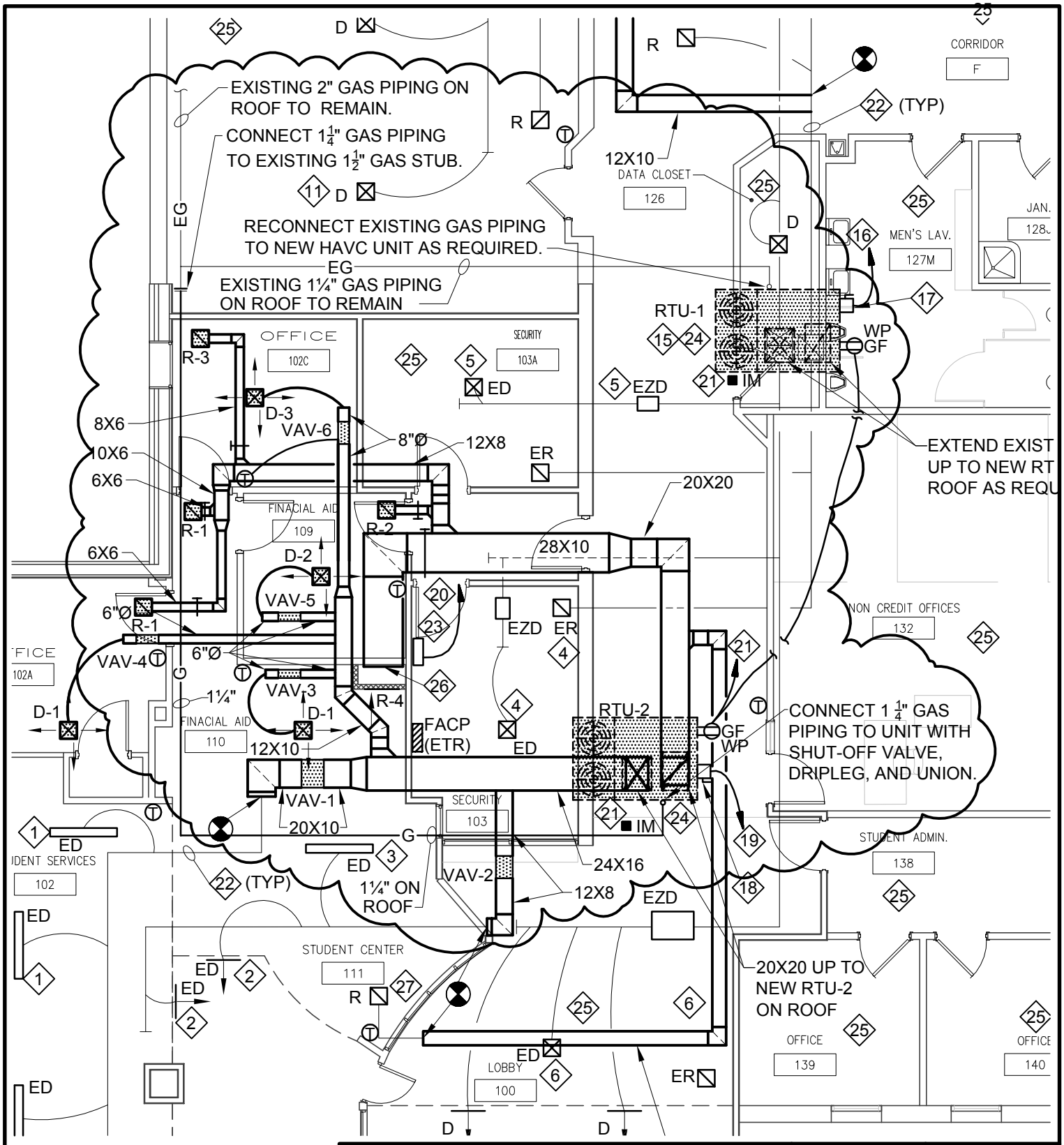
D. Damper control: the Zone damper will modulate open and close in sequence to maintain the temperature setpoint.

4.3 COOLING ONLY VAV BOX SEQUENCE

A. Occupied mode: when the zone temperature is between the occupied heating and cooling setpoints (inside of the bias), the primary air damper will be at the minimum cfm. On a rise in zone temperature above the cooling setpoint, the primary air damper will increase the cfm. On a drop in zone temperature below the heating setpoint, the damper is controlled to provide a minimum cfm.

B. Unoccupied (night setback) mode: when the air handling unit shuts down, all box controllers are indexed to unoccupied mode. When the zone temperature is between the unoccupied heating and cooling setpoints (inside of the bias), the primary air damper will be at the minimum cfm. On a rise in zone temperature above the unoccupied cooling setpoint, the primary air damper will increase the cfm (if available).

END OF SECTION 230900



TITLE: MECHANICAL REVISIONS	REF. ME2.0	PROJ. NO. 12125
PROJECT: HACC GETTYSBURG CAMPUS	DATE 10-5-12	SCALE 1/8"=1'-0"
Moore Engineering Company 3637 Columbia Avenue Lancaster, PA 17603	DRAWN BY DLE	SKETCH NO. ADM-1