**(NOTE: P/A to Complete/Delete Sections 4.02 – 4.07 and 5.01 – 14)**

PART 1 - GENERAL

1.01 BASIC REQUIREMENTS

A. Provide all labor, materials, programming, and supervision necessary to install a fully functional and operating Distributed Digital Control system (DDC) utilizing electronic actuation.

1) Minor devices, interlocks, programming, and installation details necessary to make the DDC system fully functional are to be included in this Scope of Work whether or not the specific items are specifically referenced herein.

2) The Project Architect/Engineer (PA/E) shall have the sole authority to determine if items not specifically included within this specification section are minor or significant and/or outside of this intended scope of work.

B. Only approved product manufacturers installed by an approved installing Controls Contractor per Pinellas County School Board, RFP Contract Bid #06-968-544 (DDC Manufacturer Contracts with Pinellas County School Board) shall be allowed to provide the DDC system.

Approved Combinations of Manufacturers/Controls Contractors are:

1. KMC Controls installed by Automated Building Control Systems, Inc. (ABC).
2. Trane Controls installed by Tampa Bay Trane.

C. Electrical control and interlock wiring connected to the DDC controls and associated instrumentation systems shall be furnished by the Controls Contractor.

1) Power (110 VAC circuits or higher, low voltage circuits, transformers, wiring, conduits, etc.) to DDC controllers shall be provided by the Controls Contractor.

2) All 110 VAC or greater work shall be completed by a State of Florida licensed electrical contractor.

3) Life safety devices (firestats, etc.) are not the responsibility of the Controls Contractor's Scope of Work.

4) Equipment safety interlocks shall be 110 VAC.

a) Sensing devices shall be provided by the Controls Contractor.

b) 110 VAC wiring shall be by the Controls Contractor.

c) Unless auxiliary contacts are required for interfacing device status to the DDC system, all safety devices shall be independent of the DDC system.

D. The DDC system shall consist of multiple digital controllers distributed throughout the facility; interconnected using a communication network; and programmed to maximize the integrity of the operational sub-systems being controlled.

1) Provide stand-alone distributed controllers selected and deployed to coincide with the operating sub-systems being controlled.

2) All reasonable efforts shall be made to ensure single controller failures shall affect only the sub-system being controlled.

3) Master/Slave or Centralized Controller configurations shall not be accepted.

a) All reasonable efforts shall be made to insure normal sub-system operating parameters reside at the distributed controllers and not at a higher level device to enhance the operating integrity of the DDC sub-systems in the event of a network communications failure.

b) Software shall be provided to allow distributed controllers to operate in a basic default control mode in the event of communication network failure.

E. Provide comprehensive operator and technician training as described in Part 3 of this Specification Section.

1.02 RELATED SECTIONS

1. General Conditions
2. Special Conditions
3. Section 15A Manual Specification
4. Section 16A Manual Specification
5. Section 15000 General Mechanical Specifications
6. Section 16000 General Electrical Specifications
7. This Specification Section and all its Parts, including:

1) PART 1 - General

2) PART 2 - Products

1. Paragraphs 2.01 to 2.04 – Digital Network
2. Paragraph 2.05 – Field Devices

3) PART 3 - Execution

4) PART 4 - Sequence of Operations

5) PART 5 - Operator Interfaces, Graphics, and Trending

1.03 COORDINATION WITH OTHER TRADES AND ENTITIES

A. Provide coordination with others to include, but not be limited to:

1) The Control Contractor shall supply the control valves, immersion wells, and couplings for flow and pressure switches to the Mechanical Contractor for installation by the Mechanical Contractor;

2) The Control Contractor shall supply all automatic control dampers to the Mechanical Contractor in Division 15 for installation by the Mechanical Contractor. The Mechanical Contractor is responsible for providing and installing blank‑off plates, if needed, when the control application requires dampers smaller than duct size.

a) The Controls Contractor shall review the documents for the various air dampers. If the dampers are not installed on purchased equipment, this Contractor shall be responsible to provide them.

b) Fire/smoke dampers that have only fire protection functionality are not the responsibility of this Controls Contractor. However, fire/smoke dampers shall be provided with secondary contacts for monitoring by the EMS. This Contractor shall provide the cabling from the damper secondary contact to the Field Panel.

c) Fire/smoke dampers that have a dual purpose fire/smoke and controls functionality are to be provided by the Division 15 Mechanical Subcontractor and controlled by this Controls Contractor to include actuators and field contacts.

3) Provide adequate wall space and locations for mounting of sensors, thermostats, panel enclosures, and backplanes. The Control Contractor shall be fully responsible for coordination of all sensor locations with furniture cabinets, equipment, copiers, etc.

4) Temporary controls to facilitate construction and/or required dry out support as interior finishes and materials are being installed – it shall be the responsibility of the Controls Contractor to coordinate temporary control requirements to this end;

5) Assist the Test and Balance agency efforts;

6) Assist the PA/E to validate compliance with requirements of the plans and specifications;

7) Coordination with the Owner’s Instrument Technician department to enable a remote LAN connection.

8) Coordinate conduit layouts and routing with the General Contractor, Division 16 Electrical Contractor, and other trades as required.

1.04 SCOPE OF WORK

PA/E to Provide Overview of Scope Limits

for Specific Project Requirements

1.05 SHOP DRAWING SUBMITTAL REQUIREMENTS

A. After award of the Controls Construction Contract, and prior to delivering submittal data to the PA/E, a Pre-Submittal Conference shall be scheduled by the Controls Contractor with the PA/E and Owner's Representative. The purpose of the pre-submittal conference is to review the proposed control system digital network architecture and to discuss the sequence of construction activities. It shall be the responsibility of the Controls Contractor to coordinate this meeting.

B. Submit six (6) copies of the following data/information for approval (prior to ordering any hardware or software items). Wherein this criteria differs from requirements of Related Sections, the more stringent criteria shall prevail unless otherwise directed in writing by the PA/E:

1) An overall digital system digital communication network architecture diagram showing:

a) All digital devices (PC Workstations, Field Panels, and LAN devices). Use unique panel identifiers for each panel submitted.

b) Communication transducers (fiber to copper, copper to fiber, etc.).

c) Identify entry point into the Owner’s intranet.

d) Power/surge protection locations.

e) Uninterrupted Power Supply (UPS).

f) Other pertinent devices residing on the digital communication network.

2) Physical Distributed Panel Locations:

a) Provide site and/or building floor plans.

b) Use unique identifiers for each panel submitted cross referenced to the network architecture diagram.

c) Identify the digital panel type.

d) Use a clearly thought out numbering scheme that would assist in identifying panel locations (for example: use 1-2-xx for panels in Building 1, second floor, panel XX).

e) Clarify the numbering scheme or conventions used on the interconnect diagram and the floor plan panel locations.

f) Thermostat locations after coordinating wall space availability with the General Contractor.

3) A detailed point-to-point diagram for each DDC panel:

a) Submit on a per distributed panel basis (typicals are acceptable provided all applicable units are listed, exceptions noted, and the units are identified).

b) Include each I/O point, communication connection, and power inputs to the panels.

c) Provide a means to cross reference the I/O points to field device cut sheets.

4) Cutsheets showing the performance data for all devices. Clearly mark the specific model and options to be provided. Include; but not limited to:

a) Digital Panel data (indicate whether programmable or configurable, show power requirements, A/D conversion resolution, D/A conversion resolution, panel capabilities, etc.).

b) Thermostat and other field sensor data (show accuracy, installation details, dimensions, weight, and other pertinent data relevant to the devices to be used).

c) Valve and damper schedules showing size, configuration, capacity, manufacturer, and location.

5) A detailed Sequence of Operations for each distributed panel.

6) A description of the methodology used to keep graphics files on various PC terminals updated and consistent with one another (remote computer graphics vs. site computer).

7) All schemes and methods proposed to provide lightning protection for the DDC system entering and leaving each building shall be submitted for review and approval.

C. Provide the Submittal per the following:

1) Provide in a bound (stapling not accepted) format.

2) Provide a Table of Contents and tabs for each section.

D. Wherein this criteria differs from requirements of Related Sections, the more stringent criteria shall prevail unless otherwise directed in writing by the PA/E.

1.06 AS-BUILTS

A. The Controls Contractor shall keep a full sized set of floor plans and submittal documents on-site that shall be updated daily (failure to keep active red-lined documents on-site and up-to-date may result in a delay of pay requests until the documents have been brought current).

B. As-built floor plans are to be provided and shall include, as a minimum the following content:

1) Field Panel, Workstation, Global Network Controllers (GNC), and VAV box device locations along with the associated network addresses shall be shown on a floor plan.

2) Communication device locations (repeaters, transducers, and converters).

3) Annotate via symbols all devices located above ceiling or otherwise in concealed locations.

4) Tier 1 and Tier 2 DDC system communication cable routing (delineate copper from fiber media):

a) Provide actual routing and not homeruns.

b) Provide a legend distinguishing cable type and colors of cables.

5) Power supplies and power distribution routing if power supplies are mounted remote from the powered device. Power supplies internal to Field Panels or enclosed cabinetry need not be shown on the floor plan provided enclosed cabinetry layouts are provided as a separate detail.

6) The location of AHU duct static pressure sensors and hydraulic piping pressure sensors.

7) Exhaust and relief fan locations and the controls associated with each fan.

8) Clearly and uniquely identify the connection point between the Control Network and the site intranet.

C. At the completion of the project, provide as-built drawings in AutoCAD (.dwg AND PDF format) on CD-ROM/DVD disk media. A copy of the As-Built PDF documents shall be stored on the Workstation hard drive located at the site in a dedicated folder on the root directory.

D. Update the Sequence of Operations to reflect the installed sequences.

E. Field panel to I/O device terminations need not be shown on the as-built floor plan but shall be shown on the field panel record documents.

1.07 SYSTEM WARRANTY

A. All control devices provided by this Contractor shall be warranted to be free of defects in workmanship and material for a period of two years from the project Final Substantial Completion date.

1) The first year of Warranty shall be administered through the Facilities Department or the Maintenance Department (depending on the department responsible for the project) along with the PA/E.

2) The second year of Warranty shall be administered by the Maintenance Department.

B. Any equipment found to be defective during this period shall be repaired or replaced without expense to the Owner.

C. Warranty work shall be accomplished by the Contractor during normal working hours (8 AM to 5 PM, Monday through Friday, excluding holidays).

If the Warranty call issue is found not to be a justifiable warranty call that results in charges to the Owner; then, per the Pinellas County School Board RFP Contract Bid #06-968-544 (DDC Manufacturer Contracts with Pinellas County School Board), no overtime premium would be paid after hours unless response time falls within the timeframe and conditions stipulated in the RFP.

D. The Contractor shall respond to all warranty items within one working day from when they are reported.

E. Provide a report to the Owners Maintenance Department identifying the problem, the devices affected and the nature of the repair or replacement.

F. The warranty shall cover all costs for parts, labor, shipping, associated travel, any software sequence modifications, and expenses throughout the warranty period.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with terms and conditions each manufacturer agreed to provide per RFP Bid #06-968-544, the following manufacturers are acceptable:

1. KMC
2. Trane

B. All capabilities described as available through the manufacturer’s response to the RFP (06-968-544) shall be fully implemented. No other manufacturers shall be accepted.

2.02 COMMUNICATIONS NETWORKING, PC WORKSTATIONS, AND INTEGRATION SUPPORT

A. General

1) The Digital Network shall consist of a minimum of two tiers of communication.

a) The lowest level tier shall be comprised entirely of cabling provided by the Controls Contractor which shall interconnect Controls Contractor provided digital network elements, independent of the Owner’s intranet;

b) The highest level tier shall be at the Ethernet level used for communications with other upper level devices, other Global Network Controllers on-site, or to PC Workstations (either local or remote sites) or Servers residing on the Owner’s intranet.

2) There shall be a single point of interface between the Controls Contractor provided network and the site intranet.

3) All building to building communications shall be accomplished using fiber optic interconnects.

a) The fiber optic cabling between buildings shall be provided by others under this contract and is not the responsibility of the Controls Contractor. The Controls Contractor shall coordinate their cabling plan requirements prior to submittals and reflect the cabling plan in the shop drawings.

b) The Controls Contractor shall provide the media converters from copper to fiber and vise versa.

B. Global Network Controller (GNC)

1) Provide an independent stand alone, microprocessor based control panel (Global Network Controller, GNC) for each facility.

a) Each facility shall have a minimum of one GNC as a part of the communication network.

b) The operator shall communicate with the DDC system via the PC Workstation. The PC Workstation shall obtain data from the GNC via the Ethernet trunk.

2) The GNC shall communicate to distributed Field Panels via the Controls Contractor provided cabling. Wherein multiple buildings are used, fiber optic cabling shall be used for the building-to-building trunk communication.

3) In the event the Digital Network consists of multiple Global Network Controllers, all points available on one GNC shall be accessible to all other GNCs.

4) Provide all hardware and software necessary to allow remote communications to off-site locations connected to the Owner’s intranet. Remote PC Workstations on the Owner’s intranet shall be able to communicate with the local site even if the local PC Workstation is turned off or not functioning. The Controls Contractor shall coordinate communications connectivity requirements with the Owner’s Controls Department.

5) Each GNC panel shall have a clock with battery back-up. Where there are multiple GNC panels, the respective clocks shall be synchronized by the PC or a designated GNC. Provide a minimum of 30 minute UPS for the GNC to include any attached and/or expanded I/O loads. The GNC shall shutdown or go into a power loss mode prior to the loss of power from the UPS.

6) As many GNC panels as required shall be furnished to provide the monitoring and control functions and capabilities specified. The panel shall be strategically located in areas of the building that are easily accessible for maintenance and repair.

7) The trend log, schedules and alarms shall be located in the GNC or the Field Panels and not the PC. The PC may be used to archive old trend data and/or alarms.

C. PC Workstation

1) Provide one (1) IBM compatible personal computer (PC) to communicate with the Global Network Controller (GNC). It is the intent the PC Workstation communication link would be through the Owner’s Intranet or direct connect from PC to GNC if applicable.

2) The PC shall be located at the site (location to be determined during pre-submittal conference).

3) PC Hardware - Provide a Dell PC in accordance with the current School Board contract with Dell. Contact the District for the latest model available in contract.

1. Dell High End Optiplex GX745T
2. GX745T Mini-Tower 2.4 GHz Core 2 Duo processor
3. 2 GB RAM
4. ATI 256 Megabytes VGA/DVI/TV-Out Dual Monitor Adapter
5. 160 GB Hard Drive
6. Dell Optical Mouse (NO wireless)
7. CD/DVD – 16X DVD+RW
8. 19" Flat Panel LCD monitor
9. Laser Jet printer with 3 replacement toner cartridges
10. 600 KVA UPS minimum – sized to allow a minimum of 15 minutes of backup for the PC, printer and monitor
11. NIC Card 10/100 (may be integrated into the motherboard)
12. Adobe Acrobat 6.0 Professional or most current

4) PC Software

The operator interface panel software shall be compatible with Windows XP PRO operating system with current Service Packs installed (reference RFP Bid #06-968-544 requirements). All operating system software, control software, and graphics generation software shall be provided, along with required usage licenses. All software shall be provided for the Owner to make any changes to the system without Control Contractor support (i.e., if the Owner needs to change a graphic, provide the graphic software that generated the original).

D. Field Panels

1) The Manufacturer shall have multiple Field Panels (FPs) specifically designed for HVAC applications. Panels shall be programmable and not configurable. The devices shall be stand alone. The Field Panel devices shall be able to interface with an operator and interface/room and/or zone sensor devices (Microset, Net sensor). The operator interface device shall allow the operator to adjust set points, initiate push-button actions, and receive feedback of temperature and/or status.

a) Input/Output (I/O) Interface

To gather sensor data and interface with controlled equipment, the FPs shall use I/O types consistent with the application for which it is designed. This design shall allow different types of points using any of the following input/output options:

(1) Input Options (universal; analog or digital) - monitor the open/closed status of dry contacts, monitor analog values of voltages, current and resistance from temperature, pressure, relative humidity, CO2 sensors, etc.

(2) Digital Outputs Options - control on/off, start/stop, open/close relays.

(3) Analog Output Options - supply voltage or current outputs to controllers.

b) Universal Inputs (UI)

(1) The Field Panel devices shall accept isolated dry contact closures (either normally open or normally closed contacts).

(2) The Field Panel devices shall accept analog inputs (voltage, current, resistance). Minimum 12 bit A/D converters required.

(3) Analog inputs can be linear or non-linear. Points shall include an A/D converter and an analog power supply. All points shall be wired to the FP device using #18 AWG twisted, shielded pair cables (Belden 8760 or equivalent) or larger or as recommended by the Control Manufacturer.

c) Digital Outputs (DO) - The digital outputs shall control on/off, start/stop relays which have low voltage coils. Dry contact or triac outputs are acceptable. Common ground outputs are acceptable. Provide override switches and LED status lamps on relay assembly.

(1) Enclosure Mounted—Use RIB model MUIS or equivalent.

(2) Field Mounted—Use RIB model UIS or equivalent.

d) Analog Outputs (AO) - The analog output supplies voltage or current to the control devices (i.e., damper actuator). All output points to valves and dampers shall read as a percent open. Signal types shall include 4-20 mA (into 1,000 Ohm load), resistance (up to 1,000 Ohms), and voltage (0-10 VDC). Provide a minimum 12-bit D/A converters.

2) Field panels shall include but not be limited to: AHU Control Panels, VAV Controllers, FCU Controllers, UV Controllers and EF Controllers.

2.03 PACKAGING AND ENVIRONMENT

A. Distributed Field Panel enclosures shall be locking type, metal cabinet, with common keying. The panels shall have a metal print pocket suitable for storing wiring, service and log information. Indoor panels shall be NEMA 1 hinged enclosures. Any panels in cooling tower or chemically treated areas shall be NEMA 4 stainless steel (fiberglass enclosures rated for outside applications are not acceptable). VAV box controllers shall have a safety cover but no enclosure is required.

B. Each GNC panel shall be stand alone, mounted indoors, and in a standard NEMA 1 enclosure. The electrical power requirements shall be provided by the Controls Contractor. Coordinate circuits with the Division 16 Contractor. 110 VAC power should not be installed in the same raceway channels as 24 VAC. The 24 VAC power and the 110 VAC side of the panel shall be physically isolated and clearly labeled. Fuse all transformers. Control panels shall be clearly identified by labels (1” pop-riveted lettering). Provide and install as-built wiring diagrams to indicate the control points on all equipment. Provide laminated point lists in all GNC panels if provided with I/O.

C. The panel, when required, must functionally operate over a temperature range of 20 degrees F to 150 degrees F, and a humidity range of 0 - 95% non-condensing.

D. DDC panels shall come with a minimum of six pre-existing available knockouts for ease of wiring during installation.

E. The electrical requirements shall be identified and coordinated by the Controls Contractor. Any 110 VAC requirements are to be coordinated with Division 16 Contractor. 110 VAC power circuits to each panel shall be provided by the Division 16 Contractor. 110 VAC power should not be installed in the same panel as 24 VAC. However, if 110 VAC power must be installed in the same panel with 24 VAC power due to design and/or system constraints, the 110 VAC side of the panel shall be physically isolated from the 24VAC side and clearly labeled. Fuse all transformers.

F. Control panels shall be clearly identified by permanent labels (one inch lettering), pop-rivet attached to the enclosure.

2.04 INTEGRATION TO OTHER DIGITAL NETWORK DEVICES

If integration of separately provided equipment/software is called for in the documents, then the following requirements shall apply.

A. Chillers

1) Discrete I/O Points (these points shall be provided as hardwired points to the chiller control panel and shall function without the integration interface)

1. Chilled Water Setpoint.
2. Demand Limit Setpoint.
3. Chiller enable/disable (start/stop).
4. Chiller status (Normal Run as a BI to the DDC system).
5. Chiller trouble alarm (BI to the DDC system).

Pumps associated with chillers shall be controlled via the DDC system. When a local chiller panel is used to initiate control of pumps, the local chiller panel shall provide a binary signal(s) to the DDC system. Upon receipt of the binary signal(s), the DDC system shall accordingly command an output(s) to control the associated pump(s) within a five second timeframe.

2) The Mechanical Contractor in conjunction with the chiller manufacturer shall provide the Control Contractor with the proper protocol panel for chiller control integration (i.e. BACnet, open protocol, York Talk, etc.); It shall be the Controls Contractor responsibility to clarify with the Mechanical Contractor that all hardware and software is to be provided on the chiller to interface with a non-proprietary DDC system.

a) The Control Contractor shall provide communication wiring and conduit between the Chiller integration panel and the DDC system.

b) Using the Chiller integration interface, the DDC Controller shall provide the following chiller data points on the DDC system at a minimum:

Monitor Points (as applicable)

1. Chilled Water Supply Temperature
2. Chilled Water Return Temperature
3. Condenser Water Supply Temperature
4. Condenser Water Return Temperature
5. Running kW or Amperage Output
6. Condenser Pressure
7. Evaporator Pressure
8. Compressor Discharge Temperature/Pressure
9. System Starts
10. Operating/Run Hours
11. Operational/Safety/Alarm Status
12. Status of purge
13. Purge unit run time

c) All chiller points obtained from integration shall be capable of being used in fully dynamic graphics with all the same features and functionally available to the system DDC points.

2.05 Field Devices

A. Automatic Control Dampers and Operators

1) Automatic control dampers shall have interlocking blades and frames. Dampers shall be designed and constructed so that the blades, frames and linkage mechanism shall present a rigid assembly with free and easy action.

2) Submit leakage and flow characteristics of dampers to the PA/E to specify performance. Test leakage reports shall be in accordance with AMCA standard 500‑75.

3) When dampers are located at fan discharge, they shall be sized to operate properly without fluttering. Each automatic damper or section of damper, if too large for one motor, shall be operated by the required number of modulating motors. The motors shall be of the proper size required to operate the damper with uniform and gradual movement and shall return the damper to the same position for a given signal during an opening or closing movement of the damper. Damper operators shall be of the proportional type capable of accepting 0‑10 volts or 4‑20 ma control signal and 2‑10 VDC feedback signal. The type of operator input signal shall be a function of the DDC control panel output.

4) Outdoor air damper operators shall include spring return with fail to the closed position, unless otherwise noted.

5) Approved damper manufacturers are: Metalaire, Ruskin, and Vent products.

6) The Control Contractor shall furnish all the controlled dampers of the type and sizes indicated on the drawings for installation by the Sheet Metal Subcontractor or the Mechanical Contractor.

7) All two-position control dampers shall be sized for minimum pressure drop, at the specified duct size.

8) All modulating dampers shall be sized for an effective linear air flow control characteristic within the angle of rotation and maximum pressure drop specified. Information shall be provided to the Sheet Metal Subcontractor for determining the proper duct reductions or baffles used.

9) Frames: Frames shall be 5” x 1” and manufactured with no less than .125” extruded aluminum hat channel with hat shaped mounting flanges on both sides. Each corner shall be reinforced with internal braces for maximum rigidity.

10) Damper Blades: Damper blades shall be airfoil type extruded aluminum. Each blade shall be a maximum of 6” with integral structural reinforcement for the full length of blade. Blades shall be equipped with low leakage flexible blade edge seals.

11) Blade Edge Seals: Damper blade edge seals shall be suitable for operation between 0° F and 200° F. The Control Manufacturer shall submit leakage and flow characteristics plus a size schedule for all controlled dampers. Seals shall be mechanically locked in extended blade slots and easily replaceable in field.

12) Jamb Seals: Jamb seals shall be flexible stainless steel compression type to prevent leakage between blade and frame.

13) Bearings: Bearings shall be non-corrosive molded synthetic. Axles shall be ½” plated steel hexagonal shaped to provide positive locking connection to blade.

14) Linkages: Linkages shall be concealed out of airstream within frame and easily accessible for maintenance.

15) Dampers shall be of the parallel blade design for two-position service and opposed blade design for modulating service.

16) Approved damper operator manufacturer is: Belimo.

B. Automatic Control Valves and Operators

1) The Control Contractor shall furnish all the control valves of the type indicated on the drawings for installation by the Mechanical Contractor.

2) All modulating, straight‑through, water valves shall be provided with equal percentage contoured throttling plugs. All modulating, three‑way, mixing valves shall be provided with linear, V-port plugs, such that the total flow through the valve shall remain constant regardless of the valve's position. All diverting valves shall have two, V-port plugs.

3) Valves (2" and smaller) shall have brass or bronze bodies with screwed ends. Valves (2‑1/2" and larger) shall have iron bodies brass or bronze trimming with flanged ends. Valves shall be factory rated to withstand the pressures encountered. Valves shall have stainless steel stems and spring-loaded Teflon packing.

4) Air handling unit water valves shall be sized for a pressure drop equal to the coil they serve but not to exceed five (5) psi. Valves (greater than 3") shall have replaceable seats and discs. Provide pressure drop at half flow with submittals.

5) All automatic control valves shall be fully modulating type unless specified otherwise by the Project PA/E.

6) All control valves with spring return actuators shall be designed to fail as follows:

* + - Cooling—Fail fully open to coil.
    - Heating—Fail Fully closed to coil.

7) Each valve operator shall be 4-20mA type, with spring return or manual position override and position feedback into the DDC system.

8) Ball control valves are acceptable.

9) Valves actuators shall be mounted in the vertical position only, relative to the valve body.

10) Approved valve and valve actuator manufacturer is: Belimo. The warranty on the valve actuators shall be two years minimum.

C. Current Switches

1) Provide solid state current switches which when the current level sensed by the internal current transformer exceeds the pre-set trip point. Internal circuits are to be totally powered by induction from the line being monitored. Provide Form C relay contacts, while sensing both AC and DC circuits. Provide an LED that shall show three pieces of information (Rapid Flashing-switch is tripped, Slow Flashing-current is present but below the trip point, and No Flashing-current is either off or below the bottom of the range) and permits setting the trip point adjustment prior to system connection.

2) Current switches shall be split core type and shall be non-adjustable.

D. Differential Pressure Switches

Differential pressure switches shall be furnished as indicated by the sequence for status purposes for either air or water applications. Provide single pole, double throw switch with fully adjustable differential pressure settings. The switch shall have a snap-acting, Form C contact rated for the application. The switch contact shall be rated for 5 amps at 120 volts, as a minimum. Units shall be selected for ranges consistent with the application and shall be submitted for the PA/E’s approval.

Acceptable Manufacturers: Dwyer and Cleveland

E. Electronic Temperature Sensors

1) Temperature sensors shall be thermistor or 100 Ohm platinum RTD. Sensors shall be calibrated to less than or equal to a 1/4 degree F resolution for the specific application. Substitutions must be approved in writing by the PA/E. All sensors to be field verified as correct by the TAB Subcontractor prior to testing.

2) Provide twisted pair lead wires and shield for input circuit or as otherwise required by the manufacturer.

3) Use insertion elements in ducts not affected by temperature stratification or smaller than one square meter. Use averaging elements where larger or prone to stratification. Sensor length 2.5 m or 5 m as required.

4) Insertion elements for liquids shall be brass separable sockets (i.e., thermowells) with minimum insertion length of 2-1/2 inches (60 mm).

5) Provide outside air sensors with watertight inlet fittings, shielded from direct rays of the sun. Mount on the north side of the facility.

6) The temperature sensors shall be field verified by the Installing Contractor. PA/E shall spot check and verify these calibrations during walk through inspection.

7) Wall mounted sensor shall be mounted at 5'–6" above finished floor in an area where free air current is not constricted or blocked. Final location shall be approved by the Owner and PA/E prior to installation. Wall mounted sensors in common areas (i.e. Corridors, Cafeteria, Auditorium, Gymnasium, etc.) shall be a flush mounted, stainless steel wall sensor.

8) Sensor elements shall be applicable for the medium being sensed (i.e., room elements, well mounted elements, duct mounted elements and outdoor mounted elements). Range shall be from 0 to 150 degrees F.

9) Strap on sensors shall not be used unless specifically required.

10) Provide Supply air Temperature (SAT) sensors on all units with terminal heat, powered fans, or configurations that would result in a temperature difference between the zone’s SAT and the AHU’s SAT.

F. Electronic Static Pressure Sensors

1) Static pressure sensors shall be differential pressure sensors, with the "high" output sensing the duct pressure and the "low" input sensing atmospheric pressure.

2) The range for the static pressure sensor shall be matched to the static pressure of the system being sensed, 0 to .5 inches, 0 to 2 inches, 0 to 5 inches, or 0 to 10 inches.

3) Accuracy shall be plus or minus 2% of the full range being sensed.

4) Duct Static Pressure sensors shall be provided with vinyl tubing from the sensing point to the associated AHU room. The pressure to current transducer shall be located in the AHU room.

G. Filter Status Transmitter

1) The filter status transmitter is not currently required or used.

2) Filter status switches are not to be used.

H. Humidity Sensor/Transmitter

1) Provide relative humidity sensor/transmitter where shown on the control drawings. Sensor and transmitter shall have:

1. System Accuracy 2% RH @ 25°C from 20% to 95% RH.
2. Output Signal Two-wire, 4-20 mA linear (or 0 – 10 VDC) proportional to 5%

to 95% RH.

2) The transmitter power shall be compatible with and powered by the low voltage power supplied by this Contractor.

I. Carbon Dioxide Gas Sensor/Transmitter

The Carbon Dioxide Gas Sensor/Transmitter is not currently required or used.

J. Outside Air Monitor and Control

1) Each VAV air handling unit shall have an airflow control station capable of performing constant volume control of outside air without loss of required outside air at part load.

2) Each airflow monitor and control station shall be complete with velocity pressure transmitter and air volume flow rate control.

a) Pressure transmitter ranges shall be selected such that the velocities across the air monitor sensing element are at mid-range of the manufacturer's velocity range for the sensor.

b) The Controls Contractor shall verify any outside air dampers not used to achieve the velocity requirements are disconnected and permanently secured shut.

c) The Controls Contractor shall notify the Division 15 Contractor of any outside air openings that result in bypassing the air monitor sensor.

3) The major control instruments shall be capable of the following minimum performance:

a) Differential Pressure Transducer: The differential pressure transducer shall be capable of transmitting a linear 4 to 20 ma (or 0 to 10 volts) output signal proportional to the differential (velocity) pressure input signals within the following performance and applications criteria.

1. Calibrated Spans not greater than 1-1/2 times the maximum design velocity pressure.
2. Calibrated Overall Accuracy 1.0% of span
3. Repeatability 0.05% of output
4. Operating Range of Sensor 20°F to 150°F
5. Operating Range of Transmitter 20°Fto 150°F
6. The transmitter output shall be unaffected by direction (or attitude) of mounting or external vibrations, and shall be furnished with a factory calibrated span.

4) Units to comply with minimum manufacturers up and downstream configuration, to be coordinated with Division 15 Contractor.

5) All velocity to CFM calculations shall be done in the DDC system.

6) Where called for on the AHU specifications, the AHU manufacturer shall provide the sensing station and matched velocity to signal conversion. Linearization and conversion from velocity to CFM shall be done in the DDC system.

7) When using a duct mounted air monitoring station, the sensing station shall be the responsibility of the Controls Contractor. The velocity signal shall be brought into the DDC system. Linearization and conversion to CFM shall be accomplished in the DDC system.

K. Airflow Measuring Stations (Duct Airflow Measuring Device)

1) Each device shall be designed and built to comply with, and provide results in accordance with accepted practice as defined for system testing in the latest revision of ASHRAE Handbook of Fundamentals as well as the latest revision of the Industrial Ventilation Handbook.

2) Airflow measuring stations shall be fabricated of heavy galvanized steel welded casing with 90 degree connecting flanges in a configuration and size equal to that of the duct it is mounted into. Each station shall be complete with an air directionalizer and parallel cell profile suppresser across the entering air stream and mechanically fastened to the casing, equal‑area and equal‑weighted averaging total pressure sensors and manifold, bullet‑nose shaped static pressure sensors with averaging manifold, internal piping, and external pressure transmitter ports. An identification label shall be placed on each unit casing listing model number, size, area, and specified airflow capacity.

3) The maximum allowable pressure loss through the unit shall not exceed 0.1"w.g. Each unit shall be capable of measuring the airflow rate within an accuracy of 2% as determined by U.S. GSA. Certification tests shall contain a minimum of one total pressure sensor per thirty‑six square inches of unit measuring area.

4) Stations shall be installed in strict accordance with the manufacturer's published requirements. Final location shall be coordinated with the mechanical or the sheet metal subcontractor. These stations serve as the primary signals for the airflow control systems; therefore, it shall be the responsibility of the Contractor to verify location and installation to assure that accurate primary signals are obtained.

5) The units shall have a self‑generated sound rating of less than NC40, and the sound level within the duct shall not be amplified nor shall additional sound be generated.

6) Stand-alone airflow measuring stations shall be Model FAN-E, as manufactured by Air Monitor Corporation or pre-approved substitute. Refer to schedules and floor plans.

7) Each air monitor shall be tested by the Project TAB Contractor. Tests shall be conducted at full and part load fan capacity.

L. Water Flow Switches

Provide pressure-flow switches of bellows actuated mercury type or snap-acting type, with appropriate scale range and differential adjustment for service indicated.

Acceptable Manufacturers: Dwyer or Barksdale

M. Water Flow Meter

1) Furnish a single turbine flow sensor complete with hot tap full port ball valve and installation hardware. Paddle type flow meters shall not be acceptable. Rotational sensing of the turbine shall be accomplished electronically by sensing impedance change and not with magnetic or photo-electric means. Each sensor shall be individually calibrated and tagged accordingly against the manufacturers primary standards which must be accurate to within 0.1% traceable to the U.S. National Institute of Standards and Technology (NIST).

2) The sensor shall have a maximum operating pressure of 400 PSI, maximum operating temperature of 220 degrees F, (optional 300 degrees F) and a pressure drop of less than 1 PSI at 17 feet per second flow rate. Flow sensor shall have 100: 1 turndown ratio. Accuracy shall be + 2% of actual reading from 0.4 feet per second to 20.0 feet per second.

3) The sensor shall have integral analog outputs of 0 to 10 VDC and 4-20 mA current output for connection to the DDC system. The sensor shall also include an internal frequency output consisting of 0 to 15 VDC pulses for diagnostics purposes and for connection to peripheral equipment (local display, BTU meter, etc.). All outputs shall be linear with flow.

4) The turbine element shall be made of polypropylene (optional polsulfone) with sapphire jewel bearings and tungsten carbide shafts. The flow sensor shall be constructed of plated brass (optional 316 SS) with an aluminum electronics enclosure and gasket cover (optional outdoor / submersible enclosure).

N. Refrigeration Leak Detectors

1) The Division 15 Mechanical Contractor shall provide a refrigerant leak detector specific for the refrigerant being used. This Controls Contractor shall be responsible to interface the detector with the DDC system.

2) ASHRAE-15 Standard (Safety Code for Mechanical Refrigeration) ventilation requirements are to be provided by others with pertinent equipment status inputs provided by this Controls Contractor.

3) Provide a minimum of three remote sensor inputs from the detector. Points to be provided by the Controls Contractor are:

1. Refrigerant PPM (AI)
2. High PPM (BI)
3. ASHRAE-15 Ventilation Fan Status (BI)

O. Low Temperature Limit Sensors

1) Provide low temperature protection thermostats of manual-reset type with sensing elements 8' or 20' in length. Provide thermostat designed to operate in response to coldest 1' length of sensing element, regardless of temperature at other parts of element. Support element properly to cover entire duct width. Provide separate thermostats for each 25 sq.ft. of coil face area or fraction thereof.

2) Sensors shall be provided by Controls Contractor, if not provided as an integral part of the AHU. Control circuit shall be 110 VAC and shall be provided by the Controls Contractor.

3) If called for on the documents, provide a BI to an auxiliary contact.

P. Control Wiring

1) All conductors shall be of stranded copper wire.

2) All PVC/EMT/rigid steel conduit and outlet boxes shall conform to the requirements specified under Division 16, Electrical.

3) All cabling (routed in conduit or not) shall be plenum smoke rated.

4) All wiring cables shall have 600 volt insulation and shall be provided with a bound stripping string to facilitate preparing wire terminations.

5) Conduit fittings shall be steel compression or set screw type.

Q. Variable Frequency Drive (VFD) Motor Speed Controller

(Refer to Drawings for Voltage, Size, and Location found on Pump and/or Air Handling Unit Equipment Schedules)

1) Variable Frequency Drives and other Adjustable Speed Drives/Controllers are to be provided by others and interfaced by this Controls Contractor into the DDC system;

2) Provide the following minimum hard-wired discrete inputs/outputs between the drives and the DDC system:

1. AO to control drive speed;
2. AI reference to monitor actual drive speed;
3. BO to activate the drive;
4. BI for drive failure alarm (drive fault).

3) If specifically called for on the plans, provide a communications integration interface between the drive and DDC system. This requirement shall not replace the requirement for the listed minimum discrete I/O points.

R. Temperature Thermostats (Stand-alone Split System applications, as required)

Provide UL listed, two position (i.e., On/Off) room thermostat with bimetallic sensing element, set point thumb wheel dial, room temperature indicator, surface mounting base, and hard plastic cover plate.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Each control system shall be complete with all necessary thermostats, valves, relays, switches, accessories, etc., and all interconnections and so arranged that they shall provide the proper automatic sequence of operation between the various control devices, as required to maintain the desired temperature, conditions and sequence, to provide a complete operating system. The intent of this specification is for the Controls Contractor to provide all necessary components to achieve the desired operations whether or not interposing devices are specifically shown on the documents.

B. All control equipment shall be fully modulating unless otherwise noted, and relays or accessories not specifically mentioned but required for proper operation shall be included.

C. The system shall be installed by competent personnel, who are well trained and regularly employed by the Control Contractor. Installation by the Mechanical Contractor is not acceptable, unless otherwise noted on the plans.

D. Control and instrument wiring and capillaries are to be secured to the building structure using J hooks (not to ductwork, conduits, or water piping).

E. The exact location of instruments, panel boards, accessories, etc. shall be approved by the PA/E, reviewed and discussed with the Owner during the controls pre-submittal conference.

F. All automatic controls and accessories shall be located in accessible locations.

G. All non-panel and panel mounted instruments shall be clearly labeled as to use and system served by means of engraved laminated name plates permanently attached to the device. Use pop rivets or other permanent fasteners to secure labels. Where no space exists on the device, provide a means to securely attach the name plate (or metal engraved tag) to the device.

H. Where control instruments or accessories are to be installed on covered casings, ductwork etc., they shall be mounted on a permanent surface of the equipment (not on removable covers). Care shall be taken that there are no leaks around the stems where they pass through the metal work. Provide insulation or device extensions to minimize condensate forming.

I. All modulating control valves, dampers, etc., shall operate in a slow, gradual manner without any jerking or slamming. All actuators shall be vertical and mounted above any moisture or condensate sources.

J. This Control Contractor shall furnish any necessary additional controls, relays, or damping devices, as required, to correct cycling or hunting that occurs in any part of the control system after the system is in operation.

K. This Control Contractor shall provide power to all electric actuators requiring an external power source, whether they are furnished by this Contractor or part of other equipment.

L. Electronic VAV controllers, motors, and sensors shall be provided under this scope of work. The cost of mounting controllers and motors shall be by the VAV box manufacturer. Coordinate drop shipment of controllers to the VAV box provider. Unless specifically allowed per the plans, no field installed VAV box controllers shall be allowed.

M. This Control Contractor shall furnish all motorized valves and dampers to the Mechanical Contractor for installation.

N. This Control Contractor shall receive a velocity analog signal from the outside air monitors whether the airflow monitor is provided by the Control Contractor or others. Velocity to air flow (i.e., CFM) conversions shall be accomplished internal to the DDC system using curves provided by the outside air monitor manufacturer. The resultant calculation shall be a linearized air flow reading.

1) Outside air differential pressure sensors shall be mounted outside the air handling unit and located in an easily accessible location. Provide a pneumatic, “T” connection (external to the air handling unit) to enable the TAB Contractor to measure the velocity signal without having to disconnect the signal to the differential pressure sensor.

2) All damper actuators shall be located outside the air handling unit and easily accessible.

O. Field panel assemblies shall be provided per the following guidelines:

Field Panels shall be installed in a neat and orderly manner. Standards of quality and acceptance shall be at the sole discretion of the PA/E.

P. All above ceiling devices shall have a permanently mounted label on the ceiling visible from below. Labels shall be permanent and pop-riveted to the ceiling grid or otherwise secured to hard ceilings.

Q Furnish and install as-built wiring diagrams to indicate the control points on all equipment. Also, provide laminated point lists in all control panels.

R. Provide transient voltage surge suppression on FPs, GNCs, and field devices, as required by the manufacturer.

S. Programming code shall be documented in line using REMARK statements. Any changes after acceptance shall be REMARKED, dated, and initialed by the person changing the code.

3.02 CONTROL WIRING

The following criteria shall be met. Should any deviation be required to comply with manufacturers requirements then the PA/E shall be notified of any deviations prior to installations.

A. Provide over-current protection for all control and interlock wiring.

B. Line voltage and external to enclosures low voltage control wiring shall be run in conduit in mechanical equipment rooms. Do not install low and high voltage in same conduit. J-hooks may be used above ceiling where no conduit is required.

C. No splices shall be allowed.

D. EMT conduit fittings shall be steel compression type. Set screw fittings are not acceptable.

E. Wiring Conventions:

1) Communication Wiring provided by the Controls Contractor shall be 18 gauge, 2 wire, shielded cable - GREEN in color (Belden #8760 or equivalent).

2) Field Panel I/O Wiring provided by the Controls Contractor shall be per the following:

1. Analog Inputs – WHITE
2. Analog Outputs – YELLOW
3. Binary Inputs – ORANGE
4. Binary Outputs – BROWN

3) Field Panel Power Wiring shall be BLUE with grounded secondaries, unless specifically prohibited by the Manufacturer.

F. Cables shall be properly identified/tagged with matching wire markers on both ends as to the control point. Wire marker ink shall be permanent and shall survive water and/or oil being wiped on the surface. Provide heat shrink labels on both ends of wiring.

G. Wiring installed in concealed locations (i.e., ceilings to wall temperature sensors, above hard ceilings, underground, etc.) shall be run in conduit. EMT conduit fittings shall be steel compression type. Set screw fittings are not acceptable. Conduit shall be no less than 3/4" diameter.

H. Non conduit wires (exposed wires above ceiling) shall be decided by the detail spec (project scope).

I. Any cable or wiring installed in a drywall partition must be run in a minimum of ½" conduit.

3.03 CONTROL MANUFACTURER’S FIELD SERVICES AND INSTRUCTIONAL REQUIREMENTS

A. Start-up and commissioning system: Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation. On-site training shall not begin until the system has been accepted by the PA/E and field verifications have been completed.

B. On-site Training: Provide sixteen (16) hours of training. This training shall be completed in groups of no more than 6 persons per group at one time in one four‑hour session for each group. In addition to Pinellas County School Board training, include four hours of training for the Test and Balance Representative. The training shall focus on the specific installation and shall address both hardware and software. Specific as-built documentation for this project shall be used for reference as a part of this training. Pre-submit course outline to the PA/E as stated above. A four hour training session is required for the school personnel quarterly for the length of the warranty.

C. Walter Pownall Service Center Site Training: Provide sixteen (16) hours of training at Walter Pownall Service Center. This training shall be completed in groups of no more than 8 persons at one time in one 4‑hour session for each group. This training is intended for the Maintenance Department Instrumentation Technicians.

D. For all levels of training, a sign-in sheet shall be submitted to the PA/E certifying that each individual has completed such training to the satisfaction of the instructor. Hours of instruction received shall be a part of the sign-in sheet.

E. It shall be the Owner's responsibility to provide adequate time for attendance at all training sessions.

3.04 DEMONSTRATION

General: Provide field testing and adjustment of the complete DDC and an on-site operational acceptance test of the complete operational DDC. Notify the Owner in advance of all testing activities. The Owner may witness all tests.

3.05 SUBSTANTIAL COMPLETION, ACCEPTANCE, AND WARRANTY

A. After the PA/E's verification, an acceptance test of the completed system in the presence of the Owner's representative and the PA/E shall be performed. When the system performance is deemed satisfactory by these observers and all record (as-built) drawings have been received by the Owner, that part of the system shall be considered substantially complete.

B. All control hardware, software, and firmware installed by the Controls Manufacturer or the Manufacturer representative shall be warranted by the Controls Manufacturer for a period of two years. Defects arising during this warranty period shall be corrected without cost to the Owner.

C. During substantial completion and final walk-through the Control, Mechanical, Electrical and Test and Balance contractor shall be present.

3.06 TESTING

A. The Control Contractor shall test the entire system and document the point by point operation of all controls and perform all required continuity testing of conductors prior to final connection to control equipment.

B. Substantial Completion inspections shall not be scheduled or performed until a detailed statement has been received from the Control Contractor certifying that the point-to-point checks have been completed. Also, a list of any non‑completed or improperly operating devices shall be a part of this certified statement. This list must be submitted a minimum of five days prior to a Substantial Completion inspection. A penalty of $100 per hour for the PA/E’s time shall be assessed to the Contractor if it is determined by the Owner and the PA/E that a Substantial Completion Inspection was called for when the system was not complete.

C. Provide an all points print report log (site specific) with the substantial completion inspection report as required in paragraph 1.05 B.

3.07 CALIBRATION AND ADJUSTMENT

A. After completion of the installation, perform calibration and adjustments of the Automatic Temperature Control system provided under this contract, and supply services incidental to the proper performance of the temperature control system under the warranty below.

B. Provide a detailed calibration and checkout log detailing the calibration and adjustment activities performed.

3.08 PREVENTATIVE MAINTENANCE INSPECTIONS

Preventative Maintenance Inspections shall be included within the scope of the work specified herein and shall consist of the following:

Coverage to start at Substantial Completion and extend for two years from that date.

a) The first year shall be coordinated through the District’s normal warranty process as defined under the General Conditions.

b) The second year shall be coordinated through the District’s Maintenance Department with the Controls Department Manager.

PART 4 – SEQUENCE OF OPERATION

4.01 BASIC REQUIREMENTS

A. The control sequences indicated in the specifications herein show the intended sequence of operation of the various control systems and shall be followed completely, deviations are not acceptable.

B. The Control Contractor is responsible to provide/add the required points to correctly perform the specified sequence of operation.

4.02 VARIABLE VOLUME AIR HANDLING UNIT (EXAMPLE)

A. General:

1) Each AHU shall be controlled by its own dedicated DDC control panel. Each panel shall in-turn communicate with the Energy Management Control System (EMS) over a twisted pair of wires. Provide mixed air low limit controllers to prevent the mixed air temperature from dropping below a preset level. The outside air damper shall close automatically if the mixed air drops below setpoint and send an alarm message to the printer. This damper shall require a reset through the computer terminal (manually) or automatically reset based on the outside air temperature (rise above 40°F). The system shall be capable of both reset methods.

2) A static pressure transmitter, located 2/3 downstream before the last takeoff, shall transmit a signal to the DDC control panel which shall, through its PID control loop, modulate the fan variable frequency drive in order to maintain constant setpoint.

3) Provide a high pressure sensor in the supply duct to shut-off the AHU fan if the duct static pressure exceeds the pressure setpoint (2-1/2" WG adjustable).

4) Interlock the exhaust fans per the schedule on the drawings.

5) Differential pressure switches are required for fan flow status (digital type) and for filter status (analog type) indication. Smoke detectors shall also be provided at the return air and supply air ducts of each air handling unit. The operation of the AHU is indexed by the DDC control panel from time scheduling command or from an operator command. The AHU is a variable volume unit with a chilled water coil and a hot water coil in a draw thru configuration.

6) Provide one (1) digital output (DO) per air handling unit for all restroom exhaust fans associated with that unit.

7) Provide one (1) DO per AHU for all relief fans associated with that unit.

8) Provide a separate digital input (DI) for each relief fan.

9) Provide for a partial occupancy mode in which all relief fans associated with respective AHU are de-energized and the outside air cfm is reduced to 20% (adjustable) of normal.

10) Monitor and Alarm Points:

The following points shall be monitored and alarmed at the EMS: (also see point list)

1. Outside air temp
2. SA temp air temp (heating coil and cooling coil)
3. Low limit status
4. DDC loop parameters
5. Cool output %
6. Fan status
7. Sensors norm/fail status
8. Filter norm/dirty
9. Supply air static pressure
10. Outside air flowrate (CFM)

The following points shall be operator adjustable and/or automatically reset by a EMS program:

1. Heating setpoint
2. Cooling setpoint
3. Unoccupied setpoints
4. Supply air static pressure
5. Reheat setpoint
6. Outside air flowrate (CFM)
7. Cold deck setpoint

Upon loss of communication with EMS the standalone AHU DDC controller on each AHU shall operate in occupied mode.

B. Occupied Mode:

1) Cooling Mode Control

a) The 'Cooling-Off-Heating' mode selector switch is manually placed in the 'Cooling' mode which shall send a digital signal to the main EMS panel. 'Cooling' mode is then broadcast to all local controllers. Control action shall be automatically adjusted at each controller. Changeover valves are in their 'Normal' position. At this point, no equipment is operating and the controllers are waiting and listening for further instructions.

b) Upon a timed local override signal or a scheduled start signal from the EMS, the AHU or predetermined combination of AHUs (user definable) and required combination of secondary pumps (SCHP-1, SCHP-2, HWP-1, and HWP-2) shall start (each AHU H-O-A switch is required to be in the 'Auto' position). The outside air damper shall either open upon start of the AHU fan or open according to the morning warm-up sequence described later in this Section.

c) The AHU local control panels shall begin controlling the cooling coils average discharge air temperature in the unit by manipulating the chilled water flowrate through the coil by modulating the chilled water control valve. The average discharge air temperature off of the cooling coil shall be maintained at +1/2°F to setpoint (52°F adjustable). The respective AHU local control panels shall also control the heating coil average discharge air temperature in the unit by manipulating the reheat water flowrate (from the hot water generator) through the heating coil control valve. The average discharge air temperature off of the heating coil shall be maintained at +1/2°F to setpoint (62°F adjustable).

d) Constant Outside Air Control:

(1) The air monitor shall sense total air pressure and static pressure in the outside air duct. This signal shall be converted and transmitted by the differential pressure transmitter via a 4-20 mA signal to the PCM (analog input). The signal shall be linearized and converted to a flowrate (CFM). This flowrate shall be compared to setpoint, and through the PCMs PID control algorithm, the controller shall manipulate the position of the outside air and return air dampers to control the outside air CFM. The dampers shall be manipulated using split range control, first modulating the outside air damper to its full open position before modulating the return air damper closed. A separate analog output signal shall be provided for each damper. The outside air damper and return air damper shall be controlled to maintain a constant amount of outside air throughout the AHU fan operating curve. This Contractor shall work with the T&B Contractor for calibration to these conditions and characteristics.

(2) Morning warm-up sequence shall be provided as an option for all units. During morning warm- up, the AHU supply fan is energized, the outside air dampers remain closed, interlocked relief and exhaust fans shall remain off, the VAV boxes shall be energized, and the AHU controls are energized. The outside air dampers shall remain closed for a period of 5 minutes (adjustable) or until space temperature setpoints have been met. During the period in which the outside air damper remains closed, the respective exhaust and relief fans for that system shall remain off so that system air balance is achieved and air infiltration does not occur. When the outside air dampers open and begin controlling outside air flowrate, then interlocked relief and exhaust fans shall start. Limit switches shall be provided for both the outside air dampers and return air dampers to indicate when the damper is either in the full open position or full close position. All limit switches shall be a digital input to the Energy Management System. The AHU fan shall not start if both the outside air damper and return air damper are in the full close position.

e) Static Pressure

(1) A static pressure transmitter, located 2/3 downstream before the last takeoff, shall transmit a signal to the DDC control panel which shall, through its PID control loop, modulate the fan volumetric flowrate through a variable frequency drive (4-20 mA) device (4-20 mA actuator is a part of this Base Bid).

f) The following points shall be operator adjustable and/or automatically reset by the Main Controller program:

1. Heating setpoints
2. Cooling setpoints
3. Unoccupied setpoints
4. Outside air quantity setpoints

g) Upon loss of communication with the Main Controller, the standalone AHU DDC controller on each AHU shall operate in occupied mode. Provide an H-O-A switch at the air handler to be normally in Auto position for control by the main controller. When the switch is in Hand mode, the air handler shall run continuously regardless of whether the PCM is operational or not. When the switch is in the Off position, the air handler shall shutdown. Exhaust fan interlocks shall operate through this H-O-A switch as well so that the exhaust fans interlock in the Hand mode.

2) Heating Mode Control

a) The 'Cooling-Off-Heating' mode selector switch is manually placed in the 'Heating' mode which shall send a digital signal to the main EMS panel. 'Heating' mode is then broadcast to all local controllers. Control action shall be automatically adjusted at each controller.

b) Upon a timed local override signal or a scheduled start signal from the EMS, the AHU or predetermined combination of AHUs (user definable) and required secondary heating pump (HWP-1 or HWP-2) shall start (each AHU H-O-A switch is required to be in the 'Auto' position).

c) The AHU local control panels shall begin controlling the heating coils discharge air temperature in the unit by manipulating the heating water flowrate through the coil by modulating the hot water control valve. The average discharge air temperature off of the heating coil shall be maintained to setpoint (85°F +1/2°F).

d) Constant outside air shall be controlled as described in the cooling mode.

3) Shutdown

Set the shutdown sequence schedule up to first stop flow of chilled water through the unit 15 minutes prior to stopping the air handler fan. This is to accommodate a dry down cycle.

4) Supply Air Temperature Setpoint Reset Control

a) Cooling Mode

(1) When the average space temperature is above 72.5°F, the cooling coil leaving air temperature shall be maintained at 52°F. The supply air temperature shall be allowed to vary between 52°F and 68°F as necessary to maintain the combined average of all space temperatures at 73.6°F.

(2) On a drop in the average space temperature below 72.5°F, the cooling coil leaving air temperature shall be maintained at 52°F. The supply air temperature shall be controlled to a constant 68°F (adjustable).

(3) On a rise in the average space temperature above 71°F, the cooling coil leaving air temperature shall be maintained at 52°F. The supply air temperature shall be controlled to a constant 72°F (adjustable).

b) Heating Mode

(1) Outside Air Temperature > 57°F

On a drop in the average space temperature below 71°F, the cooling coil leaving air temperature shall be maintained at 52°F. The supply air temperature shall be allowed to vary between 72°F and 90°F as necessary to maintain the combined average of all space temperatures at 71°F.

(2) Outside Air Temperature < 57°F

On a drop in the average space temperature below 71°F, the cooling coil shall close. The supply air temperature shall be allowed to vary between 72°F and 90°F as necessary to maintain the combined average of air space temperatures at 71°F.

4.03 CONSTANT VOLUME AIR HANDLING UNIT

A. General:

1) Each AHU shall be controlled by its own dedicated DDC control panel. Each panel shall in-turn communicate with the Energy Management Control System (EMS) over a twisted pair of wires. Provide mixed air low limit controllers to prevent the mixed air temperature from dropping below a preset level. The outside air damper shall close automatically if the mixed air temperature drops below setpoint.

2) Interlock the exhaust fans per the schedule on the drawings.

3) Differential pressure switches are required for fan flow status (digital type) and for filter status (analog type) indication. Smoke detectors shall also be provided at the return air and supply air ducts of each air handling unit. The operation of the AHU is indexed by the DDC control panel from time scheduling command or from an operator command. The AHU is a constant volume unit with a chilled water coil and a hot water coil in a draw thru configuration.

4) Provide one (1) digital output (DO) per air handling unit for all restroom exhaust fans associated with that unit.

5) Provide one (1) DO per AHU for all relief fans associated with that unit.

6) Provide a separate digital input (DI) for each relief fan.

7) Provide for a partial occupancy mode in which all relief fans associated with respective AHU are de-energized and the outside air CFM is reduced to 20% (adjustable) of normal.

8) Monitor and Alarm Points:

The following points shall be monitored and alarmed at the EMS: (also see point list)

1. Outside air temp
2. SA temp air temp (heating and cooling)
3. Low limit status
4. DDC loop parameters
5. Cool output %
6. Fan status
7. Sensors norm/fail status
8. Filter norm/dirty

The following points shall be operator adjustable and/or automatically reset by a EMS program:

1. Heating setpoint
2. Cooling setpoint
3. Unoccupied setpoints
4. Reheat setpoint

Upon loss of communication with EMS the standalone AHU DDC controller on each AHU shall operate in occupied mode.

B. Occupied Mode:

1) Cooling Mode Control

a) The 'Cooling-Off-Heating' mode selector switch is manually placed in the 'Cooling' mode which shall send a digital signal to the main EMS panel. 'Cooling' mode is then broadcast to all local controllers. Control action shall be automatically adjusted at each controller. Changeover valves are in their 'Normal' position. At this point, no equipment is operating and the controllers are waiting and listening for further instructions.

b) Upon a timed local override signal or a scheduled start signal from the EMS, the AHU or predetermined combination of AHUs (user definable) and required combination of secondary chilled pumps (SCHP-1, SCHP-2, HWP-1, and HWP-2) shall start (each AHU H-O-A switch is required to be in the 'Auto' position). The outside air damper shall open upon start of the AHU fan.

c) The AHU local control panels shall begin controlling the cooling coils average discharge air temperature in the unit by manipulating the chilled water flowrate through the coil by modulating chilled water control valve. The average discharge air temperature off of the cooling coil shall be maintained at +1/2°F to setpoint (52°F adjustable). The respective AHU local control panels shall also control the heating coil average discharge air temperature in the unit by manipulating the reheat water flowrate (from the hot water generator) through the heating coil control valve. The average discharge air temperature off of the heating coil shall be maintained at +1/2°F to setpoint (60°F adjustable).

2) Heating Mode Control

a) The 'Cooling-Off-Heating' mode selector switch is manually placed in the 'Heating' mode which shall send a digital signal to the main EMS panel. 'Heating' mode is then broadcast to all local controllers. Control action shall be automatically adjusted at each controller. Changeover valves 1 and 2 shall open to their normally closed ports.

b) Upon a timed local override signal or a scheduled start signal from the EMS, the AHU or predetermined combination of AHUs (user definable) and required secondary heating pump (HWP-1 or HWP-2) shall start (each AHU H-O-A switch is required to be in the 'Auto' position).

c) The AHU local control panels shall begin controlling the heating coils discharge air temperature in the unit by manipulating the heating water flowrate through the coil by modulating the hot water control valve. The average discharge air temperature off of the heating coil shall be maintained to setpoint (85°F +1/2°F).

C. Unoccupied Mode

The AHU is off, the OA damper is closed and the control valve is closed. The controls shall remain off until indexed by the EMS to operate. If the space temperature rises above an unoccupied setpoint, the unit shall cycle but the OA damper shall remain closed.

D. Shutdown

Set the shutdown sequence schedule up to first stop flow of chilled water through the unit 15 minutes prior to stopping the air handler fan. This is to accommodate a dry down cycle.

4.04 SECONDARY PUMPS

A. Each secondary pump shall be energized from the EMS on a time of day schedule or from operator input. When the manual override for an air handler is activated to run, the associated secondary pump shall run (when cooling or heating water is required to satisfy that zones air conditioning request). The EMS shall select the proper pump for operation based on Heat/Cool mode, zone temperature, and zone request, i.e., if a classroom building is manually overridden to run outside normal scheduled parameters and the system is in the cool mode, then SCHP-1 and/or SCHP-2 shall run. The EMS shall further evaluate if the cooling plant is required to run to satisfy the zone conditions. If the cooling plant is required, the EMS shall select the most efficient cool source (CH-1, or CH-20 to operate and satisfy the zone(s) condition. The EMS shall then automatically enable the plant and its required associated primary pumps, etc., to operate.

B. At design conditions, all secondary chilled water pumps shall operate, modulating their variable speed drives to maintain the loop static pressure sensor at setpoint (adjustable).

C. As the load decreases, CHW valves begin to close and the secondary loop static pressure begins to rise. In response, the secondary pumps shall modulate down in parallel to decrease the CHW flowrate and maintain the loop static pressure.

D. Further load decreases occur until the secondary pumps are at their minimum output (adjustable). Continued load decrease with the secondary pumps at their minimum operating point shall result in the other secondary pump being shutoff.

E. Further load decreases occur until the secondary pump is at its minimum operating point. Continued load decreases shall result in the modulation of the normally closed loop bypass valve to the open position. Only when there is one secondary pump operating and it is at its minimum operating point shall the loop bypass valve be the controlling element in maintaining the loop static pressure constant.

F. Upon an increase in chilled water requirements, the reverse of the above described process occurs (additional pumps shall stage ON as required).

4.05 CHILLERS (CH-1, CH-2, and CH-3)

A. The standalone DDC microprocessor based chiller control panel shall monitor and control the chillers in a standalone mode or as directed by the EMS. Perform the following chiller plant control strategies. See Section 15682 for complete coordination with chiller systems.

B. Chiller Sequencing—The EMS shall start and stop system water pumps and chillers based upon the loading of the operating chillers. The points at which chillers are started and stopped shall be designated by chiller. The chiller sequencing routine shall allow automatic rotation of chiller operation in order to equalize chiller run time.

C. On an automatic command from the EMS optimal/start program or from a manual command from the EMS operator's terminal the chilled water system shall be enabled. First the chilled water pump for the lead chiller shall start and prove flow through the evaporator bundle. Only after the chilled water pumps are proven shall the chiller start.

D. The lag chiller shall start whenever the lead chiller current draw exceeds a user definable setting or when the secondary common loop supply temperature exceeds 46°F (adjustable). The lag chiller shall also start if the secondary loop flowrate exceeds the primary loop flowrate as indicated by the magnetic flowmeters. The lag chiller shall start in a similar manner to the lead chiller start sequence. The lead chiller shall unload to match the lag chiller current draw. The two chillers shall then operate in unison as they load and unload to meet system demands. When the system current draw drops below a user definable setting, the lag chiller shall shut down.

E. Waste Heat Recovery Chiller (CH-3)—On a two minute time delay after the lead chiller starts, PCHP-3 shall start and prove flow through the evaporator bundle and then HRP-1 shall start and prove flow through the condenser bundle. Only after both chilled water and condenser water pumps are proven shall the chiller start. This chiller shall run continuously to serve as a waste heat recovery source of hot water for the reheat coils located in each air handler. The chiller controller shall automatically adjust the chillers load to maintain the leaving condenser water temperature (HWS) to its setpoint (120°F adjustable and automatically resettable based on an external 4-20 mA signal). Under normal cooling conditions, the boiler shall be off.

F. Chilled Water Reset (Required for CH-1 and CH-2)—The EMS shall allow reset of the chilled water supply temperature setpoint based on return chilled water, ambient temperature, or any other monitored point such as selected space temperature. The reset parameters shall be user selectable.

G. Chiller Demand Limiting (Required for CH-1, CH-2, and CH-3)—As part of the demand limiting scheme on the building, the EMS shall be able to monitor and reduce peak power demand through the limiting of chiller system capacity. The demand routine shall have automatic limit adjustment and shall allow automatic override based upon chilled water supply, chiller water return, and/or critical building zone temperature.

H. The DDC panel shall maintain a constant condenser supply water temperature by cycling the fans as required.

4.06 HOT WATER GENERATOR

The hot water generator shall be enabled/disabled from the EMS program schedule. The EMS shall control the tempering valve via a reset schedule dependent on the outside air temperature. The cooling mode/heating mode changeover shall be accomplished by a manual switch located in the mechanical building. The circulating pump shall be enabled when the hot water generator operates. The hot water generator shall be thermostatically controlled through its built-in control circuit to satisfy its manually adjusted setpoint.

4.07 DX SPLIT SYSTEM

Provide a low voltage thermostat to enable the condensing unit on a rise in room temperature of 2oF above setpoint and stop the condensing unit on a fall in room temperature 2o below setpoint. The thermostat shall allow the air handler fan to either run continuously or intermittently. Install the thermostat on the wall as shown or as directed by the Owner/PA/E during construction.

PART 5 – OPERATOR INTERFACES, GRAPHICS, AND TRENDING

5.01 SOFTWARE

A. Basic Interface Description

1) Operator workstation interface software shall minimize operator use and through the use of English language prompting. English language point identification and industry standard PC application software. The software shall provide, as a minimum, the following functionality:

1. Real-time graphical viewing and control of environment
2. Scheduling and override of building operations
3. Collection and analysis of historical data and dynamic data (trend plot)
4. Definition and construction of dynamic color graphic displays
5. Editing, programming, storage and downloading of global network controller databases
6. Alarm reporting, routing, messaging, and acknowledgment

2) Provide a graphical user interface which shall minimize the use of the keyboard by using a mouse or similar pointing device with a "point and click" approach to menu selection.

3) The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. Other Windows applications shall run simultaneously with the DDC software. The mouse or Keyboard shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, with concurrent annunciation of on-line DDC alarms and monitoring information.

a) Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via user-sized windows:

1. Dynamic color graphics and graphic control
2. Alarm management, routing to designated locations, and customized messages
3. Week at a Glance Time-of-Day scheduling
4. Trend data definition and presentation
5. Graphic definition and construction
6. Program and point database editing on-line

b) Report and alarm printing shall be accomplished via Windows program manager, allowing use of network printers.

4) Provide a security system that prevents unauthorized use.

Each operator terminal shall provide security for 10 users (minimum). Each user shall have an individual password. Each user should be individually assigned which control functions and menu items the user has access to. All passwords, user names, and access assignments shall be on-line, at the operator’s terminal. Each user should also have a set security level that defines access to displays and also defines what individual points the user can control.

5) Operator Activity Tracking—An audit trail report to track system changes, accounting for operator initiated actions, changes made by a particular person or changes made to a specific piece of equipment designated time frame, shall be printable and archived for future use. The operator activity tracking shall be in a tamper-proof buffer file.

6) Reports shall be generated on demand or via pre-defined schedule and directed to either CRT displays, printers, or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:

1. A general listing of all or selected points in the network
2. List of all points currently in alarm
3. List of all points currently in override status
4. List of all disabled points
5. List of all points currently locked out
6. List of user accounts and access levels
7. List all weekly schedules
8. List of limits and dead-bands
9. Excel reports
10. System diagnostic reports including, list of DDC panels on line and communicating, status of all DDC terminal unit device points
11. List of programs

7) Scheduling and Override

a) Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Schedules reside in both the PC workstation and DDC Global Network Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection or function key. Provide the following spreadsheet graphic types as a minimum:

(1) Display of Weekly schedules shall show all information in easy to read 7 day (week) format for each schedule. This includes all on/off times for each day along with all optimum start information.

(2) Holiday schedules shall show all dates that are to be holidays. Holidays shall be shown on the terminal in a graphical calendar format showing all scheduled days for a given month. User shall be able to easily scroll through the months for each year. Each day assigned as a holiday shall display as "All Off" or show "Scheduled" for that day.

(3) Event schedules shall be shown in the same graphical calendar format and manner as Holiday schedules. Event schedules allow for scheduling of special events. After an event has elapsed, control returns to normal schedule.

b) Operator shall be able to change all information for a given Weekly, Holiday or Event schedule if logged on with the appropriate security access. This includes all information that has to do with optimum start including assignments such as sensors to use and heating/cooling factors.

8) Collection and Analysis of Historical Data

a) Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.

b) Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual point or predefined groups. Provide additional functionality to allow predefined groups to be easily transferred on-line to Microsoft Excel. DDC contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions. DDC contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.

c) Provide additional functionality that allows the user to view real-time trend data on trend graph displays. A minimum of six (6) points may be graphed, regardless of whether they have been predefined for trending. The dynamic graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take “snapshots” of screens to be stored on the workstation disk for future recall and analysis. Exact point values may be viewed and the graphs may be printed.

d) System software shall be capable of graphing the trend log point data. Software shall be capable of creating x-y graphs that display multiple points at the same time in different colors. Graphs shall show point value relative to time.

e) Operator shall be able to change trend log setup information as well. This includes information to be trend logged as well as interval at which information is to be logged. All points in the system may be logged. All operations shall be password protected. Setup and viewing may be accessed directly from any and all graphics point is displayed on.

9) Application Software

The application software is the auxiliary software which shall be included in this system per the RFP bid.

a) Energy Management Software

1. Daily use
2. Monthly use
3. Daily Hi and Low
4. Monthly Hi and Low
5. Demand Limiting and Load Shedding Program

b) Maintenance Software

1. Schedule Maintenance
2. Run time accumulation for any specified equipment

c) Occupancy Software

After hour use log

10) Alarm Indication

a) System Terminal shall provide audible, visual and printed means of alarm indication. The Alarm Dialog box shall always become the Top Dialog box regardless of the application(s) being run at the time (such as a word processor). Printout of alarms shall be sent to the assigned terminal and port

b) Provide log of alarm messages. Alarm log shall be archived to the hard disk of the system terminal. Each entry shall include point descriptor and address, time and date of alarm occurrence, point value at time of alarm, time and date of point return to normal condition, time and date of alarm acknowledge.

c) Alarm messages shall be in plain English (or specified language) and shall be user definable on site or via remote communication. System shall provide a minimum of 20 user definable messages for each zone controlled.

d) Alarm shall be capable of being sent to the Walter Pownall Service Center Central Computer.

11) Energy Log Information

a) System shall periodically gather energy log data stored in the field equipment and archive the information on the operator terminal's hard disk. Archive files shall be appended with the new data, allowing data to be accumulated over several years. Systems that write over archived data shall not be allowed. System shall automatically open archive files as needed to display archived data when operator scrolls through the data. Display all Energy log information in standard engineering units.

b) System software shall be capable of graphing the Energy log data. Software shall be capable of creating graphs in x-y format that show recorded data relative to time.

c) Operator shall be able to change the Energy log setup information as well. This includes which meters to be logged, meter pulse value and what type of energy units are being logged. All meters monitored by the system may be logged. All operations shall be password protected.

d) Provide means for operator to export to a comma delimited file format all trend log data for use by other spread sheet programs. Operation of system shall not be affected by this operation. In other words, it shall stay completely on-line.

12) Controller Status

a) Provide means for operator to view communication status of all controllers connected to the system. Display shall include controller, status and error count. Status shall show if controller is communicating or not. Error count shall show actual count of communication errors between system and controllers in the field.

b) Provide means for operator to reset error count for all controllers to zero.

c) Provide capability to select alarm indication for each controller.

13) Configuration/Setup

Provide means for operator to display and change system configuration. This shall include but not be limited to system time, day of the week, date of Daylight Savings set forward/setback, printer type and port addresses, modem port and speed, etc. Items shall be modified utilizing easy to understand terminology using simple mouse/cursor key movements.

14) Dynamic Color Graphic Displays

a) Create Site Layout Color graphic including building penetration Icons, building floor plan displays with room temperatures and other building sensors values dynamically displayed. Icon links on the floor plans shall allow penetration to the building’s mechanical equipment. Provide System graphics for each piece of mechanical equipment, including air handling units, chilled and hot water systems as applicable, with dispersed dynamic data as indicated in the system point I/O summary of this specification. Points required by the sequence of operations shall also be displayed even if they are not defined by the I/O schedule to optimize system performance analysis and speed alarm recognition. Submit graphics for approval prior to system checkout. Provide as a minimum the following graphics.

(1) Site layout

(2) Building Floor plans

(3) Individual AHU graphics

(4) Central Energy Plant

1. Pumping system
2. Air Cooled Chillers

(5) FCU, EF and VAV boxes shall be shown on the floor plans, clicking on the device shall display all data associated with the device.

(6) All graphics shall provide, in addition to the system points, the following

Outside air temperatures:

1. Building CHWS temperatures (when applicable)
2. Chiller Plant, or Chiller status (when applicable)

b) The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of Auto-cad or Bitmap drawings for use in the system.

c) Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre- defined screen refresh rates.

d) Analog bars in 3 sizes, or color conventions shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale or available and displayed separately. The user shall be able to “click and drag” the pointer to change the set point.

e) Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.

f) Equipment state can be changed by clicking on the point block or graphic symbol and selecting the new state (on /off) or set point.

g) Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable. (Red-Alarm, Green-OK).

h) The windowing environment of the PC operator workstation shall allow the users to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

i) Off the shelf graphic software, Micro-gafx Designer or Coral Draw software shall be provided to allow the user to add, modify or delete system graphic displays.

j) A clipart library of HVAC and automation symbols shall be provided including fans, valves, motors, Chillers, AHU systems, standard ductwork diagrams and laboratory symbols that pertain to each project specific. The user shall have the ability to add custom symbols to the clipart library.

**END OF SECTION**