DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.2 SUMMARY

A. This Section includes a complete and functional direct digital Energy Management Control System (EMCS) as specified herein. The EMCS Contractor shall have total system responsibility for the installation including the following:

1. Non-BACnet Installations: Furnish and install all software, hardware, data base, conduit, wire, cable, building level network control units, floor level network control units and required connections for a complete and functional system to monitor and control points as specified, including software and data base generation, loading, debugging, and start-up.

2. BACnet Installations: Furnish and install a totally native BACnet-based system including applicable software to be installed on an Owner provided operator workstation (OWS) in accordance with this specification. All building controllers, application controllers, and input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135-2001, BACnet. Provide all software, hardware, database, conduit, wire, cable, building level (supervisor) controllers, floor (unit) level controllers and required connections for a complete and functional system to monitor and control points as specified, including software and database generation, loading, debugging and startup. Third party controllers to be connected on the MS/TP Link if possible. If other communications type is needed, CMU must approve. Provide all necessary BACnet-compliant hardware and software to meet the systems functional specifications. Provide Protocol Implementation Conformance Statements (PICS) for windows-based control software and every controller in the system.

a. Operator Workstation Software:

1) All applicable software to facilitate direct connection to the building EMCS.
2) Any necessary software/hardware “keys” required for EMCS communication software.
3) Any additional hardware cabling or equipment that may be required to facilitate direct connection to EMCS field devices (Serial Communication adapters, etc.)

Standard mode of connection is BACnet over IP for BAC installations.

3. IP Addresses, Subnet Mask and Gateway Addresses to be provided by Owner. Standard mode of connection shall be BACnet over IP unless approved otherwise by Owner. Network registration is required of Ethernet connected devices. Owner will be notified of all Ethernet connected devices, physical hardware locations and MAC addressing. Owner will provide one UDP port per building. Use of default BACnet UDP ports is not allowed.

4. Generation of color graphic displays at the existing graphic terminal for each mechanical system connected to the system. Graphics to include all dynamic point data information associated with each major mechanical system and set points.
5. Provide complete hardware and software documents, controller backups, shop drawings, operating and maintenance manuals and classroom training of operators and maintenance personnel at the site. Provide as-built control drawings in CAD format to Owner.
6. Provide a dedicated power supply to each controller cabinet and communications interface. Provide manufacturers recommended grounding to each controller cabinet, and dedicated 120V, 20A circuit with locking clip on breaker. Clearly label circuit in panel.
7. Accomplish acceptance tests, including point-to-point verification, with alarming verification including messages for all critical alarm and life safety points. Typical points requiring messaged alarming include but are not limited to:
    a. Control air compressor
    b. 24 hour fans and pumps (i.e. Freeze Protection)
    c. Critical temperature and humidity control areas (i.e. Archiving/Museum)
    d. Critical pressure control areas and systems (i.e. Laboratories and Lab Systems)
    e. Critical systems (i.e. Fire and Security)
    f. State/Federally regulated areas (i.e. Animal Areas)
8. Provide connections for all electrical devices provided by the EMCS contractor to the controllers.
9. Provide proper marking and identification of all devices, wiring, and controls. Equipment labels should indicate device name, address, room location, etc.
10. Schedule all non-24 hour equipment in accordance with generally approved University guidelines for energy usage and in accordance with the Owner. Non-24 hour equipment shall be scheduled as soon as practical to avoid excessive use of University resources prior to turnover to the University.
11. Provide any additional support that may be required to facilitate full integration of all control devices, including hardware communication troubleshooting with 3rd party devices (Variable Frequency Drives, packaged controllers, etc.).
12. Demolition Requirements: Demolition shall include removal of all associated control components (sensors, switches, etc.), wiring, and database at the front end (point definitions, programming, etc.)
13. Guarantee.

B. The EMCS Contractor shall bid directly to and be contracted directly by the General Contractor or Construction Manager.

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. RTD: Resistance temperature detector.

1.4 SYSTEM DESCRIPTION

A. The temperature control system shall be of the DDC type, connected to the University's present Energy Monitoring and Control System.

Include item B below only for BACnet installations.

B. BACnet implementations shall be functionally verified on EMCS located in the University's Central Energy Facility.

C. BACnet implementation shall be completely based on ANSI/ASHRAE Standard 135-2001, BACnet, and is to control all listed equipment using native BACnet-compliant components. Non BACnet-compliant or proprietary equipment or systems (including gateways) shall not be acceptable and are specifically prohibited. Any device designated to act as a BACnet Broadcast Management Device (BBMD) shall be designed for and dedicated to that purpose.

D. System controllers (Supervisor) connected to floor level (Unit level)(via BACnet MS/TP) devices shall perform all necessary MS/TP network routing to facilitate network efficiency and reduce communication and control lag.

E. All materials and equipment used shall be standard components, regularly manufactured for Control Systems and shall not be custom designed especially for this project. All components shall have been thoroughly tested and proven in actual use, and shall include, but not be limited to:

1. Controller cabinets with all electronics and transducers, including on-board communications capability and database memory battery back-up. Provide latest revision firmware and largest available memory board.
2. Communications interface devices.
3. Printed circuit assemblies, point modules.
4. Auxiliary device enclosures.
5. Control and status relays.
6. Current transformers.
7. Thermowells (Mechanical Contractor shall install wells furnished by the EMCS contractor)
8. Temperature and pressure transmitters.
9. Water flow sensors and transmitters.
10. Electric to pneumatic transducers.
11. Pneumatic to electric transducers, standard shall be 0 to 20 psi unless noted otherwise, include brass fittings on all pneumatic devices.
12. Power supplies to controller cabinets, transducers, and other control devices.

1.5 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

B. Shop Drawings:

1. Submit complete shop drawings of the proposed EMCS for approval including sequence of operation, valve ranges, DDC logical points and physical addresses, typical system information such as fan CFM, voltage, FLA, HP, GPM, etc.
2. Submit complete shop drawings of the proposed EMCS system for approval including, but not be limited to the following:

a. I/O point summary with recommended set points, start/stop times, time delays, etc.
b. Operator and hardware point numbers, logical names and user names.
c. Controller unit schematic wiring, layout sheet including logical point names, valve ranges, etc.
d. Fan and mechanical system schematic diagrams showing EMCS sensor locations, including valve ranges, CFM, voltage, FLA, GPM and areas served.
e. One-line diagrams for sensors, control points, and terminations, including labeling to controller cabinets, with all components, signal values, and cables.
f. Terminal cabinets, including labeled terminal blocks.
g. Connections to existing loops, controls, and panels.
h. Internal and external wiring of relays and contacts.
i. Schematic of all major equipment provided.
j. Operator, maintenance, and software programming manuals.
k. Spare parts list and prices.
l. Complete sequence of operation, description, control logic flow diagrams, and completed programming sheets in manual form for each mechanical system controlled.

3. All manufacturer's drawings, catalog cuts, and specifications shall be properly identified with the Engineer's project number and title. Each piece of equipment shall be properly identified as to its location and equipment number. Verify Equipment numbering with the Owner.

4. SUBMITTALS data relevant to panel schedules and other pertinent equipment information requiring approval prior to field installation shall be forwarded from the EMCS Contractor. Upon receipt of approval, the EMCS Contractor shall proceed with installation, set-up, calibration and check out of the various control and monitoring systems. At the completion of components and systems installation the Contractor shall request in writing that the Owner inspect and approve satisfactory operation as specified under "Acceptance Procedure".

C. As-built Drawings:

1. At the completion of the project as-built drawings shall be submitted to the Owner, showing conduit size and location, cable and wire identification, panel and sensor locations, and device layouts with panels, branch circuit numbers, and wiring diagrams for each type of typical field point wiring and for each specific variation, and data trunk riser diagram.

2. Furnish 3 sets of neatly drawn as-built diagrams of the temperature control systems, complete with sequence of operations, valve ranges, cabinet layout sheets, point logical names and physical addresses. One set to be mounted in plastic covers located in control cabinets in the field, two sets to be delivered to Construction Representative for Archives and records. One set of AutoCAD as-built drawings on CDROM shall be furnished to Design Representative to be delivered to Engineering and Architectural Services. File naming convention shall be as determined by Owner.
3. EMCS Contractor is to keep a current marked-up copy of as-built drawings on site at all times once installation started.

D. Operations and Maintenance Manuals:

1. The system shall be provided with complete maintenance and operation instructions including, but not limited to the following:

a. Complete electronic schematic wiring diagrams for printed circuit boards, DDC Controller cabinets and other equipment included in these Specifications.
b. Complete instruction set in manual form for operation of the system.
c. Complete instruction set in manual form for adding and deleting of points and interface device panels including all relevant parameters such as descriptor inputs, point types, change-of-state type, functions, etc.
d. Complete diagnostic and troubleshooting procedures set in manual form.
e. Complete instruction set in manual form for all software and firmware.

2. Any updates to firmware, software, and hardware shall be fully documented at or before the time of delivery.

1.6 INPUT/OUTPUT SUMMARY FORM

A. The following I/O Summary Form is a sample form illustrating the typical information required of the various building systems. Any device connected to the EMS that is also controlled by some local device (e.g.: light switch, P.E., high limit stat, twist timer, etc.) must be defined as an DI point. Provide dry contact from local device to digital input at controller and programming necessary to accomplish sequence of operation.

A/E to insert I/O Form, or indicate its location here if it is included elsewhere in the project documents.

B. Typical control points connected to the EMCS system are as follows:

1. HVAC/H&V Systems:

a. Supply fan (status and control).
b. Return fan (status and control where fan is not interlocked w/supply).
c. Mixed air temperature.
d. Heating coil temperature.
e. Cooling coil temperature.
f. Discharge air temperature.

g. Return air temperature.
h. Return air relative humidity.
i. Damper control.
j. Steam valve control.
k. Cooling coil control.
l. Humidifier control.
m. Space humidity sensor (where humidity control is critical).
n. At least one space temperature sensor per system or zone.
o. VAV - Static Pressure Sensors.
p. VAV - Variable Frequency Drive Remote Enable/Disable.

q. VAV - Variable Frequency Drive status.
r. Flow stations on VAV systems.
s. Occupancy override (when required).

2. Hot Water Heating Systems:

a. Hot water heating pump (status and control).
b. Hot water heating supply temperature (at each convertor).
c. Hot water heating return temperature (at each convertor).
d. Hot water heating common supply temperature.
e. Hot water heating common return temperature.
f. Steam valve control.

3. Chilled Water Systems:

a. Absorption chiller (status and control)
b. Chilled water supply temperature.
c. Chilled water return temperature.
d. Condenser water supply temperature.
e. Condenser water return temperature.
f. Chilled water supply temperature reset.
g. Chilled water pump status.
h. Condenser water pump status.
i. Cooling tower fan status.
j. Valve control on loop systems.
k. Cooling tower VFD when applicable(enable/disable/speed/status).
l. Primary chilled water supply temperature.
m. Primary chilled water return temperature.
n. Secondary chilled water supply temperature.
o. Secondary chilled water return temperature.
p. Variable flow systems to include pressure sensors and flow measurement.

4. Snow Melting Systems:

a. Enable/Disable and system status.
b. Pump Status.
c. Hot Water Supply.
d. Hot Water Return.
e. Steam valve control.

f. Sidewalk moisture/temperature sensor.

5. Miscellaneous Building Systems:

a. Outdoor air temperature.
b. Temperature control air compressor low pressure alarm.
c. Fire (trouble circuit).
d. Fire (fire alarm circuit).
e. Domestic hot water temperature.
f. Steam condensate flow meter (pulse accumulator).
g. Steam condensate conductivity (alarm).
h. Steam condensate temperature.
i. Cooling tower water treatment conductivity (alarm).
j. Cooling tower water treatment PH (alarm).
k. Domestic water flow meter (pulse accumulator).
l. Electric meter(s) (pulse accumulator).
m. Animal room temperatures.

Include freezer control point below only on a request from the Department/User.

n. Freezer ambient temperatures.
o. Exhaust fans (status and control) including:

1) Toilet exhaust.
2) Laundry exhaust.
3) General exhaust.
4) Snack bar exhaust.
5) Kitchen hood exhaust.
6) Serving hood exhaust.
7) Dish washer hood exhaust.

p. Sump pit (high water alarm).
q. Emergency generator status.
r. Microprocessor fault indication.
s. Building steam shutoff valve
t. Street light control and status.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with ASHRAE Standard 135 for DDC system components.

Include Item C below only for BACnet installations.

C. Comply with ASHRAE Standard 135-2001, BACnet where applicable.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

C. Salvaged Materials and Components: Existing control components (Building Controllers, Application Specific / Advanced Application Controllers, Point Expansion Components, etc) when removed from the field as part of a controls replacement or upgrade shall be returned to the owner for reuse or recycling at the owner's discretion.

1.9 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

1.10 WARRANTY

A. The EMCS system shall be guaranteed for a period of two years after final approval by the Owner. The guarantee shall be provided for a completely installed system, including all components, parts, and assemblies of the EMCS. The guarantee shall cover parts, materials, and labor to locate and correct any defects in materials or workmanship.

B. The Contractor shall initiate the warranty period by formally transmitting to the Owner commencement notification of the period for the system and devices accepted. The warranty period begins when these devices are formally accepted by the Owner (refer to ACCEPTANCE PROCEDURE below).

C. Contact information shall be provided for quick service engineering assistance concerning hardware and software problems. There shall be provisions made for getting manufacturer certified diagnostic and repair personnel on the scene quickly should the need arise. There shall also be a software expert familiar with the software of this machine who can be easily contacted.

D. This system shall be inspected by the EMCS Contractor for a four-hour period once each month during the warranty period to run diagnostic tests and also provide maintenance instructions to the operating personnel.

E. The EMCS Contractor shall give the Owner 24 hours prior notification of each maintenance trip during the contract guarantee period. In addition, the Contractor shall furnish the Owner and Engineer a written record of each maintenance trip, number of employees present, time involved and work accomplished.

F. Owner shall be able to make changes to database, when prior database is stored on disk in case of error in change, without affecting or voiding warranty.

1.11 MAINTENANCE

A. The EMCS Contractor shall provide and maintain on site at CMU working spare parts for the EMCS system during the warranty period including DDC Controllers, power supplies, modules, sensors, floor level (subnet) devices, transformers, etc. CMU will be custodian of these spare parts and shall be authorized to utilize them in performing first level maintenance. The EMCS Contractor shall refurbish/replace spare parts in exchange for failed items.

PART 2 - PRODUCTS

2.1 CURRENT SENSORS (TRANSFORMERS)

A. Current sensors used for monitoring motor operation shall be sized according to motor horsepower. The output shall be compatible with the EMCS field device with necessary interfacing transducers provided.

B. The current sensors shall have mounting brackets for attachment to the motor starter enclosure.

C. Manufacturers: Functional Devices, Inc. (RIB) or approved equal.

2.2 CURRENT SENSING RELAYS

A. Current sensing relays shall be used for monitoring motor operation, and sized according to motor HP.

B. Manufacturers: Functional Devices, Inc. (RIB) or approved equal.

2.3 TEMPERATURE DETECTORS

A. Temperature detectors shall be wire wound or thin film platinum resistance type sensors, or 10K Ohm thermistor type, referenced at 77 degree F, either having a minimum accuracy of + 0.5^{o} F over the noted range. All sensors of a particular category shall be of the same type and manufacturer.

B. Resistance Temperature Detectors (RTD) shall be two-wire type, and shall be provided with local 4-20 MA signal conditioning transducers shall be provided where necessary. The minimum temperature range for all sensors will be 20 ^{o}F. to 120 ^{o}F. Sensors shall have a maximum time constant of three seconds per degree change. Sensors shall not require recalibration at any time. Where required, linearizing, ranging, and resistance change versus temperature curve interpretations shall be made by software programming at the CPU or Controller. Minimum room temperature sensor range is 40-90 degree F. Wider range may be required for special applications.

C. Temperature detectors shall be either stem or tip sensitive types. Sensors installed outdoors, in piping systems, and in corrosive environments shall be hermetically sealed in type 316 stainless steel enclosures, with all joints and closures Heliarc welded. Soldering or brazing is not approved. Entire assembly, including external trim, shall be a watertight, vibration proof, heat resistant unit.

D. Sensing elements installed in piping systems shall be provided with separable wells constructed of type 316 stainless steel. Elements shall be inserted into the wells with appropriate heat transfer compound.

E. Sensors installed outdoors shall be of weatherproof construction, protected from sunlight and wind effects with a stainless steel protective shield.

F. All duct mounted temperature sensors shall be of the averaging type, with 17' or 25' long sensing elements. Averaging elements shall be installed across the full airflow area in a serpentine fashion, on rigid supports designed specifically for mounting of such elements. The averaging element shall be protected against vibration and wear at each point of contact with the element supports. Strain on the element shall be relieved at the junction box to prevent tension on the internal electrical connections.

G. Rigid stem averaging sensors will be allowed where duct size is smaller than 3' square.

2.4 STATIC PRESSURE TRANSMITTERS

A. Static pressure transmitters shall be industrial quality, capable of transmitting 4-20mA analog output signal proportional to differential (static) pressure input signals. Transmitter shall have a minimum 1% accuracy rating over the range of the device, zero and span adjustment, and stainless steel case.

B. Manufacturers: Approved by Owner.

2.5 ELECTRONIC TO PNEUMATIC TRANSDUCERS

A. Accessories: In-line filter, dual valve and gauge.

B. Manufacturers: Approved by Owner.

2.6 DAMPER END SWITCHES

A. Damper end switches shall be two position, encapsulated non-mercury style mounted on the shaft arm, SPDT, unless noted otherwise. Where electronic actuators are used and switches provided with actuator will be allowed.

2.7 EMCS CABLE

A. All EMCS cable shall be installed in conduit. EMCS cable shall comply with manufacturer's recommendations. Separate raceway systems shall be supplied for Class I and Class II circuits.

B. Data transmission trunk cables and equipment grounding procedures shall meet the latest FCC guidelines (FCC rules, part 15, subpart J) for electromagnetic field generation.

C. No splicing of RS-485 or RS-232 data cabling shall be allowed. Communication trunk shall be installed per manufacturers recommendation for operation at 19,200 baud or higher, continuous daisy chain with no tees and trunk terminators installed where appropriate. All communication and analog input wiring shall be AWG size as recommended by manufacturer with Teflon jacket.

D. Splicing of temperature sensor cable is not allowed.

E. Splicing of binary status or command cable shall take place at the field cabinet or motor starter only.

2.8 DDC CONTROLLERS

A. Controllers shall be complete assemblies consisting of modular hardware including power supply, microcomputer, input/output modules, termination modules, and battery. Battery shall be non-rechargeable lithium with 10-year life, and be capable of supporting all memory within the control unit if the house power to the unit is interrupted or lost for a minimum of 60 days total down time.

B. Controllers shall be furnished as newest revision level with largest available memory configuration unless prior approval by Owner. Verify controller type to be used in design with Owner. Most recent revision firmware shall be supplied unless otherwise noted. Each controller shall be provided with 20% spare point capacity. All controllers shall be provided with floor level (MS/TP) network capability and H-O-A switches at the output points unless approved otherwise by the Owner.

C. All points from a given mechanical system shall reside in the same controller.

D. Each Controller cabinet shall be able to monitor the following types of inputs:

Analog Inputs	Digital [Binary] Inputs
4-20 mA	Dry contact closure
0-10 VDC	Pulse accumulator
1000 ohm [10K Ohm]	

E. Controller cabinets shall directly control pneumatic and electronic actuators and control devices. Each control unit shall be capable of providing the following control outputs:

Analog Outputs	Digital [Binary] Outputs
4-20 mA	Motor starters, sizes 1 to 4

0-10 VDC

F. All temperature control functions shall be executed within the same DDC Controller. Loop control shall be executed via direct digital control algorithms. The user shall be able to customize control strategies and sequences of control, and shall be able to define appropriate control loop algorithms and choose the optimum loop parameters for loop control. Upon Owner request the EMCS shall demonstrate stable loop control by utilizing test cabinet simulation program and trending the data. Control loops shall support any of the following control modes:

1. Two position (on-off, slow-fast, etc.)
2. Proportional (P)
3. Proportional plus integral (PI)
4. Proportional, integral, plus derivative (PID)

G. It shall be possible to fully create, modify, or remove control algorithms within a specific DDC Controller while it is operating and performing other control functions. Input for these changes may be made directly into the DDC Controller or via the network. Each control loop shall be fully user definable in terms of:

1. Sensors/actuators that are part of the control strategy.
2. Control mode.
3. Gain.
4. Control action.
5. Sampling time.

H. DDC Controllers shall be able to share point information such that control sequences or control loops executed at one control unit may receive input signals from sensors connected to other DDC Controllers within the network. If the network communication link fails or the other DDC Controller malfunctions, the control loop shall continue to function using the last value received from the Controller.

I. The system shall permit the generation of job-specific control strategies that can be activated in any of the following ways:

1. Continuously.
2. At a particular time of day.
3. On a pre defined date.
4. When a specific measured or controlled variable reads a selected value or state.
5. When a piece of equipment has run for a certain period of time.

J. Upon a loss of commercial power to any DDC Controller, the other units within the network shall not be affected and the loss of operation of that unit shall be reported at the designated operator's terminal. All control strategies and energy management routines defined for the DDC Controller shall be retained during power failure via the internal battery for a minimum of eight (8) hours. Upon resumption of commercial power the control unit shall resume full operation without operator intervention. The unit shall also automatically reset its clock such that proper operation of timed sequences is possible without the need for manual reset of the clock.

K. Location of DDC Controller cabinets shall be approved by the Owner prior to installation, and documented on as-build drawings.
L. Enclose and install control devices and equipment such that they will not be subject to vibration, excessive temperature, dirt, moisture, or other harmful effects or conditions beyond their rated limitations. If devices must be located to be subjected to conditions beyond their recommended or rated limitations, provide the necessary protective enclosures or furnish the equipment constructed of materials and features capable of withstanding the adverse conditions. Controls and devices subject to moisture or to the weather shall be corrosion resistant weather tight enclosures.

M. DDC programs shall follow CMU standard form and shall include discrete sections of code that are not intermingled with other sections of control, per the following:

1. Increment line numbers by 10 or more. First line number shall be greater than or equal to 10, last line number shall be less than or equal to 32000.
2. Place all time-based commands (e.g. WAIT, TOD, SAMPLE, LOOP) such that they are evaluated each pass through the program.
3. Include comments describing each section of code.
4. Section A shall include all diagnostic, power return, emergency point and other related code.

5. Section B shall include all equipment schedules.
6. Section C shall include all DDC and other equipment control.
7. Section D shall include all two-speed sequencing, alarm delays, alarm limits and miscellaneous code, and odd month determination.
8. Each DDC program shall include the alarm indicators code in Section A. Each DDC program shall include code in Section E that initialize the run time totals on all equipment defined for totalization.
9. Any air handling unit with a heating coil controlled through DDC shall include programming which places the unit in special operation on discharge sensor failure to prevent freezing of the heating and cooling coils.
10. Each controller cabinet shall include only as many programs as is necessary for programming modularity and ease of troubleshooting. If device operation is such that the existence of multiple programs within a single control has an effect on system performance or control timing, the presence of these multiple programs must receive prior approval by the Owner. Multiple programs , if present, shall be independent in functionality and shall not perform similar or identical functions (i.e. Start/Stop, Time of Day, etc.). Each program shall be tested utilizing a test cabinet simulation to verify program functions properly, prior to loading in field cabinet.

N. Hot Water Heating Systems designed with 100% backup shall alternate pump/converter operation based on Odd/Even month per CMU standard programming. If a pump fails to operate, the backup pump shall be commanded on and a critical messaging output shall be sent to the appropriate destination (refer to item 1.2.A.6).

O. Point entry shall follow these conventions:

1. Descriptors: AI: use range of device, e.g. 20-120; AO: use range of device and normal position of device, e.g. NC 3-15 (normally closed 3 to 15 PSI); DO: use valid commands, e.g. ON OFF: DI use word STATUS.

2. Alarmability: All alarmable points shall be displayed on EMCS graphics.

3. Critical Alarming: All critical alarm points shall trigger an audible alarm at CMU Central Energy Facility.
4. Change of Value Limit: No less than 2% and no greater than 10% of range of device.
5. Engineering Units: DEG F, AMPS, PPM, IN WC, PCT RH, PSI, CFM, GPM, etc.
6. Command String and State Descriptors: These two shall typically match each other. Some common entries are ON/OFF, ENABLE/OFF, OPEN/CLOSE, FAST/OFF/SLOW, ON/OFF/AUTO.
7. Totalization: All points that indicate the run-time of a piece of equipment shall be included in this summary with time totalized per hour.
8. Contact State Descriptor: Fire alarm and fire trouble points: use a period for both states. Control air compressor: use a period for the normal state and LOW for the off-normal state. Avoid using the words NORMAL and ALARM as state descriptors for alarmable points. Return to Normal Printouts: Yes, in all instances. Critical Alarms shall not report their return to normal state to via a message to the critical messaging output device unless approved by the Owner.

9. Naming convention shall follow CMU Standard and approved. Standard is BuildingInitials_Controller_PointDescriptor. (RO_AHU11D_SpaceTemperatureLocal)

2.9 ADVANCED APPLICATION CONTROLLERS

A. Each DDC controller shall be able to extend its performance and capacity through the Use of floor level (subnet), advanced application controllers (AAC).

B. Each AAC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each AAC shall be a microprocessor-based, multi-tasking, real-time digital control processor, and fully programmable.

C. Terminal Box Controllers - Provide control of individual pieces of equipment including, but not limited to, the following:

1. Variable air volume (VAV) boxes.
2. Constant air volume (CAV) boxes.
3. Unit Conditioners.
4. Unit Ventilators.

D. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences.

E. Each controller performing space temperature control shall be provided with a matching room temperature sensor. Each room temperature sensor shall be provided with a terminal jack to be used to connect a portable operator’s terminal to control and monitor AAC points, set point adjustment dial, temperature indicator, and override switch.

F. A dedicated power source and separate isolation transformer for each AAC Power Trunk shall be provided. Transformer shall be mounted in a separate auxiliary enclosure.

2.10 APPLICATION SPECIFIC CONTROLLERS

A. Application specific controllers (ASCs) shall NOT be utilized unless approved by the Owner prior to project bid.

2.11 ELECTRONIC ACTUATORS

A. Unless approved otherwise by the Owner, all actuation shall be electronic with capacitive return or spring return (critical applications).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install engraved laminated plastic nameplates under each instrument in the control panel to designate its function.

B. All devices connecting to EMCS such as contactors, motor starters, electric pneumatic transducers, pressure electric transducers, resistance temperature detectors, relays, terminal box controllers, etc., shall be marked with the same point number used on the shop drawing SUBMITTALS for the system so as to identify the point and its function for University field service personnel. Marking shall be done with gummed paper tags installed on the surfaces that have been steel wool cleaned and sprayed with clear enamel for waterproofing.

C. Wire shall be color coded according to the Construction Representative's directions.

D. Dedicated circuits shall be installed in branch lighting panels to serve controller cabinets. Circuit breakers shall be equipped with locking clips, and shall be clearly identified.

E. All Controller Cabinets and auxiliary enclosures shall be supplied with engraved phenolic nameplates permanently attached identifying their field cabinet number, area, fan systems controlled, etc.

F. Special equipment shall be installed in accordance with manufacturer's instructions and recommendations of Service Engineer where specified or required. All control instruments, valves, etc., shall be carefully adjusted and set for proper operating of the equipment served as noted herein or as required by the equipment manufacturer's instructions and recommendations.

3.2 FIELD QUALITY CONTROL

A. Upon completion of the work, the EMCS Contractor shall instruct the Owner's Operating Engineer and acquaint him with all of the operating characteristics of all equipment installed by him including the EMCS and all other systems, at the same time operating each and every system individually for a period of two days, unless otherwise specified. During this two-day period the building's Operations Manual shall be used for reference.

B. During system commissioning and at such time acceptable performance of the installed system hardware and software has been established, the Contractor shall provide on-site operator instruction to the Owner's operating personnel. Operator instruction during normal working hours will be performed, by a competent contractor representative, familiar with the computer's software, hardware, and accessories.

C. At a time mutually agreed upon during system commissioning as stated above, the EMCS Contractor shall give an absolute minimum 24 hours of instruction to the Owner's designated personnel on the operation of all equipment included in the project. Operator orientation of the automation system will include, but not be limited to equipment functions, commands, advisories, appropriate operator intervention required in responding to the system's operation, and any other training needed in the operation of the system. An Owner's manual prepared for this project by the Contractor will be used in addition to the instruction. Six (6) manuals shall be provided.

D. Additional instruction time as deemed necessary by the Owner shall be provided by the Contractor as an extra service, and will be paid for in accordance with the State Prevailing Wage Rates for Engineers and Technicians.

3.3 ACCEPTANCE PROCEDURE

A. SUBMITTALS data relevant to point index, functions limits, sequences, interlocks, power fail/restarts, logs, software routines and associated parameters, and other pertinent information for the operating system and database shall be forwarded from the EMCS contractor to the Owner.

B. Approved database will be entered into the central computer, debugged, and down line loaded to Controllers. Prior to on-line operation, a complete demonstration and readout of the computer command shall be performed in the presence of the Owner. In addition, a printout of the database generated for all points, shall be reviewed with the Owner by the EMCS contractor. Modification to the database shall be made by the EMCS contractor as directed by the Owner.

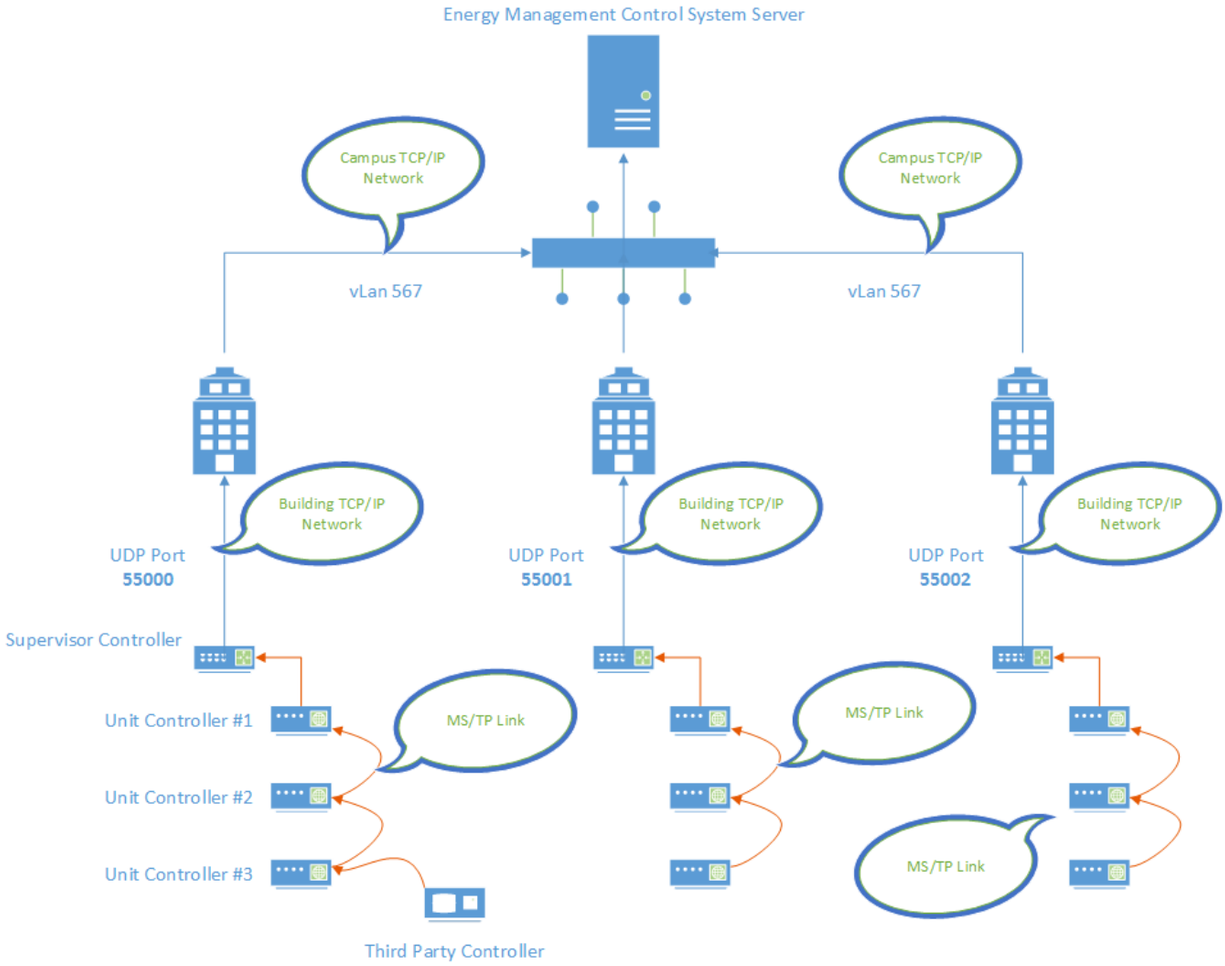
C. All points shall be verified prior to "punch-out" for correct and accurate correspondence between the CRT data display and actual field location and equipment operation.

D. The Contractor shall maintain dated and initialed calibration and verification sheets and provide a copy to the Owner. Include verification of enhanced alarming with messages for all points selected by the Owner. Typical points with messages include control air compressors, 24 hour fans and pumps, critical systems and animal areas. Point verification sheets should be submitted to the Project Manager and a copy sent to the CMU Controls Dept.

E. Upon successful completion of system generation the Owner shall be requested in writing to inspect and approve the satisfactory operation of the EMCS, sub-systems, and accessories.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls


Energy Management Control System Server
Campus TCP/IP Network
Campus TCP/IP Network
vLan 567
vLan 567
Building TCP/IP Network
Building TCP/IP Network
Building TCP/IP Network
UDP Port 55000
UDP Port 55001
UDP Port 55002
Supervisor Controller
Unit Controller #1
Unit Controller #2
Unit Controller #3
MS/TP Link
MS/TP Link
MS/TP Link
Third Party Controller

Space	Time	Winter		Summer		
		Temp (°F)	Relative Humidity (%)	Temp (°F)	Relative Humidity (%)	Comments
Laboratories	Occupied	68	30-70	73	30-70	
Laboratories	Unoccupied	65	30-70	76	30-70	
Non-Lab (Offices, Gyms, Conf. Rooms)	Occupied	70	30-70	75	30-70	+/- 2 °F Adjustment
Non-Lab (Offices, Gyms, Conf. Rooms)	Unoccupied	67	30-70	78	30-70	
Large Instrument Rooms	24/7	70 +/- 2°	40-60	70 +/- 2°	40-60	4% RH rate of change per month
Small Instrument Rooms	24/7	70 +/- 2°	40-60	70 +/- 2°	40-60	4% RH rate of change per month
Animal Holding Rooms	24/7	68	30-70	73	30-70	Same as labs with no setback
Herbarium	24/7	68	30-70	73	30-70	User desires less than 50% RH. No special systems in place
Mech./Elec. Rooms	24/7	55	N/A	90	N/A	
IDF Rooms	24/7	70	20	75	80	
Misc	24/7	55	N/A	90	N/A	

1. Network Types – Contractors will follow CMU standards for network numbering for BACnet networks. CMU will supply vendors/contractors with the required network numbers as needed. Table below:

Network	Ethernet	MS/TP (System Level)	Proprietary	IP	MS/TP (Subnet)
Numbering	1	2	3	4	5

One of the single digits above will be the first number in all the BACnet networks at CMU.

Example, Building 15 at CMU shall be identified as 11500, 21500, 31500, 41500 or 51500, depending on network type.

2. Device Instances – Contractors will follow CMU standards for device instances (IDs). Buildings are numbered #1-99, and will be assigned by CMU. CMU will supply contractors the required range of ID's. Contractors will be asked to supply an electronic copy of the IDs and associated equipment upon completion.

Building #15 Example			
	Building #15	AHU-1	VAV-1
Main Area Device (Only one per building, must be BBMD capable)	Device Instance = Building Number x 10,000 (=150,000)		
System Device (Main Equipment, AHUs, Chillers, Boilers, etc. Up to 98 per building)		Device Instance = System Number X 100 + Main Area Device Instance (=150,100)	
Subnet Device (For VAVs, Fan coils, small equip)			Device Instance = Subnet Number X 1 + System Device Instance (=150,101)