

UNIVERSITY OF CALIFORNIA, SANTA BARBARA

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SANTA BARBARA • SANTA CRUZ

OFFICE OF DESIGN & CONSTRUCTION SERVICES and PHYSICAL FACILITIES

CONTRACTING SERVICES  
Building 439  
Santa Barbara, California 93106-1030  
Telephone (805) 893-3356  
Fax (805) 893-8592

**SENT VIA:**  FAX ON THIS DATE  
 HAND DELIVERY ON THIS DATE  
 FEDERAL EXPRESS ON THIS DATE  
 UNITED PARCEL SERVICE ON THIS DATE

HOLDERS OF PLANS AND SPECIFICATIONS:

Cage Wash, Biological Sciences Bldg. II, Bldg 571  
Project No. FM090221L/981640

**Addendum No. ONE**

February 26, 2010

Enclosed is **ADDENDUM NO. ONE** to the Construction Documents on the above-captioned project.

Bid date has been changed from Thursday, March 4, 2010 at 2:30P.M. to **Thursday, March 11, 2010 at 2:30P.M.**, to be held at:

CONTRACTING SERVICES  
Facilities Management, Bldg. 439,  
Door #E, Reception Counter  
University of California, Santa Barbara  
Santa Barbara, CA 93106-1030.

Late arrivals shall be disqualified. Please allow time for unforeseen traffic delays, securing a parking permit and potential parking problems.



Anna Galanis  
Director, Contracting Services

UNIVERSITY OF CALIFORNIA, SANTA BARBARA

ADDENDUM NUMBER ONE

to the

Construction Documents

February 26, 2010

GENERAL

The following changes, additions or deletions shall be made to the following document(s) as Indicated; all other conditions shall remain the same.

I. ADVERTISEMENT FOR BIDS

Item No.

1. Second page, sentence beginning with "Bid Deadline:" **CHANGE** to read in it's entirety as follows:  
"Bid Deadline: Sealed bids must be received on or before 2:30P.M on Thursday, March 11, 2010. Sealed bids will be received only at Contacting Services, Facilities Management, Building #439, Door "E", Reception Counter, University of California, Santa Barbara, Santa Barbara, California 93106-1030."

II SUPPLEMENTARY INSTRUCTIONS TO BIDDERS

Item No.

1. Number 4. **CHANGE** to read in it's entirety as follows:  
"Bids will only be received on or before the Bid Deadline: 2:30P.M., Thursday, March 11, 2010, and only at: Contacting Services, Facilities Management, Building #439, Door "E", Reception Counter, University of California, Santa Barbara, Santa Barbara, California 93106-1030."

III INFORMATION AVAILABLE TO BIDDERS

Item No.

1. Number 5, Reports. **ADD** the following report:  
"StemCell & Cage Wash, Slide Presentation, 2-10-10, prepared by James Gonzales. Report available to bidders at: <http://facilities.ucsb.edu/contracts/bid/>"

IV SPECIFICATIONS

Item No.

1. Section 15910, Building Management System. **REPLACE** in it's entirety with attached "Revised Section 15910, Building Management System, Revised per Addendum One.

V DRAWINGS

Item No.

1. A1.06, 6<sup>th</sup> Partial Floor Plan. **REPLACE** in it's entirety with attached "Revised A1.06, 6<sup>th</sup> Partial Floor Plan, Revised per Addendum One", dated 2/25/2010.

Item No.

2. A1.07, 7<sup>th</sup> Partial Floor Plan. **REPLACE** in it's entirety with attached "Revised A1.07, 7<sup>th</sup> Partial Floor Plan, Revised per Addendum One", dated 2/25/2010.

END OF ADDENDUM NO. ONE

REVISED SECTION 15910

Revised per Addendum One

BUILDING MANAGEMENT SYSTEM

PART 1 GENERAL

1.01 APPLICATION OF THIS SECTION

- A. This Section applies to the Building Management System control and monitoring of all heating, ventilating, and air conditioning, and plumbing and electrical systems as specified. Coordinate with applicable Sections as required.

1.02 SECTION INCLUDES

- A. Network controller's hardware, operating and application software.
- B. Network communications architecture.
- C. Electronic hardware and software.
- D. Instruments, sensors and controllers.
- E. Panels and accessories.

1.03 RELATED SECTIONS

- A. Section 01010 - Summary of Work, for performance verification
- B. Section 01030 - Alternates.
- C. Section 01700 - Project Closeout.
- D. Section 13850 - Fire Alarm and Detection System.
- E. Section 15050 - Basic Mechanical Materials and Methods.
- F. Section 15057 - Variable Frequency Drives and Controls.
- G. Section 15180 - Heating and Cooling Piping.
- H. Section 15831 - Fans and Ventilators.
- I. Section 15840 - Air Terminal Units.
- J. Section 15920 - BMS Field Equipment.
- K. Section 15930 - BMS Sequence of Operation.
- L. Section 15950 - Testing and Balancing of HVAC Systems.
- M. Section 16050 - Basic Electrical Materials and Methods.
- N. Section 16120 - Conductors and Cable.
- O. Section 16131 - Conduit.

- P. Section 16132 - Surface Raceways.
- Q. Section 16140 - Wiring Devices.
- R. Section 16405 - Distribution Equipment.

1.04 SUBMITTALS WITH PROPOSAL

- A. Bidding Documents: Identify current issue of Drawings and Specifications upon which proposal is based. Include copy of Document 00010 - Table of Contents, and Document 00015 - List of Drawings.
- B. Compliance Statement: Submit technical proposal in full compliance with requirements stated herein. All bids must indicate compliance to the Specifications on a line by line basis with reference to each Specification paragraph. Likewise, all bids must indicate compliance to the Drawings. Bids for the integrated Building Management System shall be prepared and submitted by the manufacturer's authorized building branch office which is responsible for the project location territory. Bidders must be within a 50 mile radius of the project.
- C. Base Bid and Alternate Techniques: System shown and specified is Base Bid. Parallel system equipment, inherently different from the base bid but performing the same functions, may be submitted in the form of deviations. Provide full statement of compliance and/or deviation from the Contract Documents, and itemize as add or deduct to the Base Bid. Failure to provide complete disclosure of compliance/deviation shall be deemed sufficient cause for rejection of proposed BMS Manufacturer.
- D. Exceptions and Deviations: List exceptions taken to Drawings and Specifications on a line by line basis with reference to the Specification paragraph. List proposed deviations for review by A/E and University. Failure to provide complete disclosure of compliance/deviation shall be deemed sufficient cause for rejection of proposed BMS Manufacturer.

1.05 SUBMITTALS: Follow Section 01300.

- A. Submit shop drawings and product data as single complete submission. Partial submissions will be rejected without review. Exception: Control valve and damper schedules and airflow stations schedules, with product data, may be submitted separately. Allow four week A/E review period.
- B. Shop Drawings:
  - 1. System Architecture: Show location of each MCU's, TCU's, Controllers, gateways, routers, repeaters, auxiliary equipment, I/O devices, panel and other major system components.
  - 2. System Flow Diagrams:
    - a. Show location of devices, interconnections, wire numbers, pneumatic tubing, junction boxes, computer I/O connections, bulkheads, grounding, and terminals.
    - b. Include indication of control algorithms or logic used for each system in the sequence of operation. Provide logic tables where ever possible to easily communicate interlock or failure logic
    - c. Prepare on minimum 11 inch x 17 inch size drawing.
    - d. Provide a unique flow diagram for each system. Typical drawings are not acceptable. Each drawing shall identify each instrument with a unique tag number.
  - 3. Installation Overview Drawings: Provide the following:
    - a. BMS Communication riser diagram including ancillary devices such as repeaters, routers and gateways.
    - b. Typical Installation details for different types of control devices (example: end switches for dampers/valves, control panel floor stands).

4. Instrument Index: For all systems, provide a complete list of furnished instruments. Provide instrument description, manufacturer, model number, and device range.
  5. Electrical Diagrams: Include motor starter and VFD control wiring diagrams, depicting safeties and automated start/stop contacts. Coordinate with Divisions 13 and 16, and Section 15057.
  6. System Sequence of Operation: Highlight differences from Contract Documents. Provide for each independent mechanical system.
  7. Valve Schedule: Include valve curves (flow versus percent open), service (e.g. hot/chilled/condenser water or steam), quantity, actuator spring ranges, sizes, capacity in GPM for water (Lbs/hour for steam), CV of valve, pressure drop across valve in psi and shutoff ratings.
  8. Damper Schedule: Include damper leakage rating, service (e.g. 2-position vs. modulating), quantity, system served, indicate parallel or opposed blade, actuator spring ranges, damper actuator torque rating, damper section sizes (width by height), and shutoff leakage ratings.
  9. Instrument Mounting/Field Connection Diagrams: Include pipe, tank and duct mounting details for each sensor type provided.
  10. Panel Layout/Diagrams: Include bill of material and mounting details for recessed, semi-recessed, surface-mounted and freestanding panels. Provide installation details and mounting requirements. Custom panel designs shall be submitted to the A/E for review prior to fabrication.
- C. Product Data:
1. Include technical bulletins and catalog data for each control system component. Clearly identify service of each item, by use of symbol or tag number. Each product data sheet shall clearly reference page and paragraph number of specification section to which it applies. Clearly indicate complete model number, along with accessories/options, being provided. Failure to comply with this requirement will result in automatic rejection without review.
  2. Submit complete data on controllers, instrumentation and software. Include signal type, signal characteristics and ranges, installation instructions, calibration data, typical alarm printouts, advisory messages, logging formats, and other pertinent data.
  3. All material and equipment shall be listed, labeled or certified by Underwriters Laboratories, Inc., where such standards have been established. Refer to specification 15050.
- D. Design Data: Submit design data indicating sizing and selection of valves and damper actuators.
- E. Verification Reports: Submit sample forms to be used for installation and operational verification reports. These reports shall be submitted to the General Contractor and become part of University's documentation.
1. Installation Verification Report; include as a minimum:
    - a. Device tagging verification.
    - b. Point-to-point wiring and tubing verification; include identification of wires.
    - c. Verification that system is installed in conformance with design documents.
    - d. Instrument calibration verification.
  2. Operational Verification Report; include as a minimum:
    - a. Control loop tuning verification (P, P/I, P/I/D). Provide printout of tuning parameters for each loop.
    - b. Verify testing of each system's sequence of operation (e.g., cooling mode, heating mode, alarm reporting, trending, etc.).
  3. Each report shall provide space for manufacturer and University signoff.

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- 1.06 INFORMATIONAL SUBMITTALS: Follow Section 01300.
- A. Terminal Operation and Program Manuals.
  - B. Manufacturer's installation, start-up and adjustment instructions.
  - C. Certificates:
    - 1. Certify that products meet or exceed specified requirements. Include products which are not produced by control system manufacturer.
    - 2. Certify that specified manufacturer's field services have been performed and that products or systems meet or exceed specified requirements.
  - D. Software Submittal: Required for submission to University.
    - 1. Systems based on function module (configurable) programming techniques shall submit:
      - a. General operational sequence of operation for each system, detailing all setpoints and switch-over points.
      - b. Annotated function module flow drawing for each application.
      - c. Detailed description of each function module.
    - 2. Systems where application programs are provided in coded form (line-by-line programming or pre-programmed application subroutines) shall submit:
      - a. General operational sequence of operation for each system, detailing all setpoints and switch-over points.
      - b. Detailed functional explanation of each application program and subroutine.
      - c. Annotated flow charts for each application program.
  - E. Start-Up and Site Acceptance Test Procedures.
  - F. Start-Up and Site Acceptance Test Reports.
  - G. Demonstration and Instruction Statement from University.
  - H. Field installation verification reports.
  - I. Field operational verification reports.
  - J. Calibration reports for instrumentation.
  - K. Field Service Reports.
  - L. Project Record Documents: Follow Section 01700.
    - 1. Revise shop drawings to reflect actual installation and operating sequences. Show final set points and final adjustments of controls.
    - 2. Submit all project record drawings in AutoCAD Release 2008 format on DVD media. Include all related sequences of operation.
    - 3. University's acceptance of submittal will be required prior to final payment.
  - M. Operation and Maintenance Data:
    - 1. Include systems descriptions, set points, control settings and adjustments.
    - 2. Include recommended inspection and maintenance schedule, cleaning methods, cleaning materials and calibration tolerances.
  - N. Recommended Spare Parts List.
- 1.07 SEQUENCING AND SCHEDULING
- A. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.

- B. Coordinate installation of system components with installation of mechanical systems equipment.

#### 1.08 MAINTENANCE SERVICE

- A. Furnish maintenance service for one year from Date of Substantial Completion. Maintenance service shall supplement warranty provisions of the General Conditions, and shall include the following:
  - 1. On-Line Service: Provide diagnostic and troubleshooting services via telephone link-up.
  - 2. Software Maintenance and Consultation: Review need for software modifications to project database quarterly and implement modifications.
  - 3. Software Revisions (Updates): Provide revisions as they become available.
  - 4. Repair and Replacement: Provide materials and labor for repair and replacement of failed equipment and components.
  - 5. Programmed Preventative Maintenance: Schedule and perform regular and systematic preventative maintenance during a minimum of four inspection periods a year. Each inspection period shall consist of two (8 hour) working days.
  - 6. Emergency Service: Provide emergency service, between scheduled preventative maintenance calls, including overtime necessary to keep equipment and components in proper operation.
  - 7. Recalibrate combination temperature/humidity sensors annually.
  - 8. Recalibrate duct-mounted humidity, temperature, and pressure transmitters annually.
  - 9. Perform service with factory-trained service representatives employed by system manufacturer.
- B. Include 24 hour-per-day, 7 day-per-week emergency callback service.
- C. Response time: 2 hours or less.
- D. Continuing Maintenance Service: Provide a continuing maintenance proposal from Installer to University, in form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.
- E. Provide guaranteed maximum pricing for five additional years to perform duties identified in paragraphs A through D above.

#### 1.09 CONSTRUCTION MEETINGS

- A. The control contractor shall attend regular University/Architect/Contractor meetings. The control contractor shall provide a Project Manager who will attend meetings for the duration of the construction schedule.

### PART 2 PRODUCTS

#### 2.01 MANUFACTURERS

- A. Johnson Controls Inc.; Metasys System Extended Architecture for all supervisory, Master Controller Units (MCU), or network controller applications. Metasys Field Equipment Controller (FEC) Series is to be used for all field controllers or Terminal Control Units (TCU).

#### 2.02 BUILDING MANAGEMENT SYSTEM ARCHITECTURE

- A. General Description: The new BMS system shall include the newest version of both software and hardware for networked BMS control panels, Network Automation Engine, all field



controllers, PC-based system management workstations and PC-based servers. System shall employ a modular design to facilitate expansion in functionality and capacity; and provide Internet access with programmable password security. System shall employ strategically located stand-alone controllers which shall include an Uninterruptible Power Supply (UPS) in each enclosure.

- B. The Building Management System (BMS) shall provide integration of multiple building functions such as mechanical equipment monitoring and control, site utility monitoring, energy management routines, historical data trending, alarm management, lighting control, fire alarm system interface and terminal equipment control.
- C. Update all site BMS data bases and graphics to include new work.
- D. Air terminal units shall be controlled by electronic controllers connected to a local communication bus, allowing diagnostics and programming from any point on system. Provide a trend report, by each AHU/EF system, listing all the supply and exhaust air valves air flows. Include the air valves setpoints, output position signals. Trend shall provide a totalized per area/floor summarization to assist the building testing and balancing contractor in determining any duct leakage or the building peak zone static pressure requirements.
- E. In normal operation, components comprising the BMS system shall communicate over its own independent\_LAN. However, control panels and controllers shall function independently in stand-alone mode, in the event of management workstation, BMS-server, or LAN failure.
- F. The design of the BMS shall network supervisory stations and stand-alone MCU's. The BMS communication network architecture shall consist of two levels: the upper tier (MCU's, supervisory stations) shall be a high performance peer-to-peer network and the lower tier (TCU's) shall be a polling type local area network (LAN).
- G. Upper Tier Peer-to-Peer (Ethernet Communications Data Highway) Network Level:
  - 1. Supervisory stations and MCU's shall directly reside on a network such that communications may be executed directly between Controllers, directly between supervisory stations and between MCU's and supervisory stations on a peer-to-peer basis.
  - 2. Systems that operate via polled response or other types of protocols that rely on a central processor, file server, or similar device to manage panel-to-panel communications may be considered only if a similar device is provided as a standby. Upon a failure or malfunction of the primary central processor, the standby shall automatically, without any operator intervention, assume all BMS network management activities.
  - 3. All operator devices either network resident or connected via dial-up modems shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.
  - 4. Network design shall include the following provisions:
    - a. Provide high-speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any DDC shall be displayed at supervisory station and alarm printers within 5 seconds.
    - b. BMS shall support any combination of MCU's and supervisory stations directly connected to the peer-to-peer network. A minimum of 32 devices shall be supported on a single network.
    - c. BMS shall provide message and alarm buffering to prevent information being lost.
    - d. BMS shall provide error detection, correction and retransmission to guarantee data integrity.
    - e. BMS shall provide synchronization of real-time clocks, to include automatic daylight savings time updating between all MCU's.

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5. The BMS platform shall support Web-based technology, whereby TCP/IP protocols are used, to permit remote access to the BMS via the Internet. Security access and firewall protection must be fully reviewed and approved by the University prior to initializing the software. Provide all technical literature related to this subject for review by University's Information Technology Group.
- H. Lower Tier BMS Local Area Network Level (LAN):
1. The communication on this level shall support a series of TCU's and shall communicate bi-directionally with the peer-to-peer network, through MCU's, for transmission of global data.
  2. TCU's shall be arranged on the LANs in a functional relationship manner with MCU's. For example, a VAV terminal unit controller shall be on a LAN from the MCU that is controlling its corresponding AHU.
  3. A maximum of 100 TCU's may be configured on an individual MCU LANs to insure adequate global data and alarm response times.
- I. Distributed Control: Control architecture shall parallel that described herein.
1. PC-based workstations and servers.
  2. Upper Tier Ethernet Local Area Network (LAN), with minimum acceptable number of Master Controller Units (MCU).
  3. Lower Tier TCU LAN, with minimum acceptable number of Terminal Control Units (TCU), along with repeaters, as required.
  4. Provide quantity of fiber-to-copper LAN converters as required.
- J. Transient Surge Protection:
1. Provide each controller and sensor with means of suppression of transients from inductive devices in system, capable of generating or sustaining transients.
  2. Electrically isolate transmission lines from MCU and Supervisory Station by means of optical couplers at each interface to prevent voltages in network from damaging electronic circuitry.
  3. Provide Supervisory Station with immunity from electrical sags, surges, transients, noise and outages with uninterruptible power supply.
  4. Provide lighting surge protection for communication links entering buildings from outdoors.
- K. Distributed Data Base:
1. Data Base Definition: Information stored in each microprocessor shall drive device memory pertinent to performance of device, which may be utilized to perform functions of other devices in systems. Provide minimum three second update on any point polled.
  2. Supervisory Station Data Base shall identify and describe location and characteristics of system points connected to BMS.
  3. On command, up-load/down-load Data Base of MCU units connected to data highway to/from Supervisory Stations.
  4. MCU Unit Data Base: Contains information pertinent to configuration of control loops and values of process variable being controlled; determines how control is performed and what inputs will be utilized; and monitors operational status, set point values, and other pertinent data.
  5. Permit Facilities operator to modify points within Data Base. Include adding, deleting and modifying, required additions or ranges, engineering units, mode of operation and others. Other operators shall be limited to access as defined by University, via multiple security levels.
  6. Points shall be global type, accessible by data base of any controller.
  7. Permit addition of new points from Supervisory Station, or MCU, when proper field hardware devices are installed.
  8. Permit future points to be grouped into new system and building displays, substituted for existing points within existing systems, or added to existing systems.

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## 2.03 COMMUNICATION LINKS

- A. Lower Tier Data Highway: BACnet MS/TP Protocol, peer-to-peer, multiple master protocol based on token passing which shall remain operational when multiple nodes have failed.
  - 1. Highway speed: Minimum 9600 baud.
  - 2. Standard Bus: U.L. listed, Belden three or four wire twisted, shielded, jacketed cable.
- B. Upper Tier Ethernet Local Area Network (LAN):
  - 1. Communication Rate: 10 Mbps or higher.
  - 2. Standard Bus: EIA/TIA Category 5 or better 4-pair Unshielded Twisted-Pair Cable (Cat. 5, UPT). Outer jacket shall be plenum-rated where required.
  - 3. Alternate Bus: 62.5 or 50 micron multi-mode fiber optic cable.
- C. Transient Surge Protection:
  - 1. Provide each controller and sensor with means to suppress transients from inductive devices in system, capable of generating or sustaining transients.
  - 2. Electrically isolate transmission lines from MCU and Supervisory Stations by couplers at each interface, to prevent voltages in network from damaging electronic circuitry.
  - 3. Provide Supervisory Stations with immunity from electrical sags, surges, transients, noise and outages.
  - 4. Provide lightning surge protection for communication links entering buildings from outdoors.

## 2.04 UNINTERRUPTIBLE POWER SOURCE (UPS)

- A. Manufacturer: Liebert Accupower, American Power Conversion, Exide, Best Power Technologies, Deltec. Substitutions are not permitted.
- B. Provide at each supervisory station and controller. Devices for controller shall be installed inside the control cabinet.
- C. Provide protection from power surges, spikes, blackouts and brownouts.
- D. Provide immunity from electrical sags, surges, transients, noise, and outages.
- E. Performance:
  - 1. Output Voltage Regulation: Plus or minus 5 percent.
  - 2. Output Frequency Regulation: Plus or minus 1 percent.
  - 3. Output Harmonic Distortion: 5 percent total, 3 percent single harmonic.
  - 4. Output Overload Capability: 125 percent for 1 second causes shutdown without hardware damage.
  - 5. Transient Suppression: Tested to IEEE 587.
  - 6. Battery Reserve: 15 minute typical at full load for MCU controllers; 10-15 minutes with a typical PC load for Supervisory Stations.
  - 7. EMI/RFI: Complies with FCC Part 15J, Class A.
- F. Electrical:
  - 1. Input Voltage: Single Phase, two-wire plus ground.
  - 2. Input Frequency: Plus or minus 1 percent.
  - 3. For Supervisory Stations, provide UPS with quantity of outlets for CPU, Monitor, and printers.
- G. Environmental:
  - 1. Operating Temperature: 32 to 95 degrees F.
  - 2. Relative Humidity: 0 to 90 percent non-condensing.

- H. Battery: Internal, sealed, captive electrolyte, non-corrosive, no flammable gases.
- I. Provide "UPS trouble alarm" signal to BMS.
- J. Provide a manual bypass switch permitting scheduled maintenance or UPS replacement without power disruption.

## 2.05 MODULAR CONTROL UNIT (MCU)

### A. Controllers, General: Field Equipment controller (FEC) series.

1. Stand-alone, multi-tasking, multi-user, minimum 16 bit CPU-based controllers for all applications. All controllers shall provide for direct interface to industry standard sensors and input devices.
2. Provide one MCU controller per air handling unit (AHU) system. Control associated manifolded exhaust fans by separate, dedicated MCU controller. Miscellaneous exhaust fans shall be controlled from slaved controller.
3. Support dial-in and dial-out communications via industry standard modem. Modem shall have selectable baud rate between 9600 to 56.6K. Include printer connection for hard copy recording of trends, maintenance time reminder, reports, energy management reports, and alarms.
4. Include multi-level user access control, password protected. At highest level of access, allow operator to select overrides and change database.
5. Include minimum 1 MB of memory. Maintain programming in non-volatile memory or 72 hour battery backed RAM. Each unit shall have an accurate real time clock that can be synchronized from a Supervisory Station or any MCU on data highway.
6. Permit readout of variables, override of control, modification of attributes and scheduling changes while printing messages, trends, reports or alarms.
7. Each MCU panel shall contain analog inputs (AI), digital inputs (DI), analog outputs (AO), or digital outputs (DO).
8. Each MCU shall contain all input/output points necessary to provide control and monitoring of connected system in accordance with the sequence of operation. Whether the control is a fixed point type or has plug-in point modules, provide at least 20 percent spare points in each MCU for future expansion. Spare points shall contain a combination of all point types. Spare points of only one type per panel are not acceptable. List quantity and type of spare points available per controller on the shop drawing submittal. Under no circumstance shall all input/output points in a controller be totally used. A spare point is defined as a physically connected input/output module or card that is included in the project. Spare points shall be included either directly on the controller or through the addition of a separate expansion module that is mounted and connected to the controller. Blank chassis for future I/O modules is not acceptable. In addition to physical spare points, MCU shall include 20 percent spare memory to allow for future code expansion.
9. Incorporate LED status lights in MCU to indicate operational position of digital outputs (ON/OFF).
10. Controllers shall provide operators with the ability to manually override automatic or centrally executed commands at the MCU via local, point discrete on-board Hand/Off/Auto override switches for digital control type points and gradual switches for analog control type points. Override switches shall be operable whether the panel processor is operational or not.
  - a. Switches shall be mounted either within the MCU key accessed enclosure or externally mounted with each switch keyed to prevent unauthorized overrides.
  - b. MCU shall monitor the status of all overrides and inform the operator that automatic control has been inhibited.
11. MCU shall count multiple pulse type inputs (kW meters, steam flow meters and similar inputs) and convert those pulse signals into engineered values for control and read-out.
12. Permit outputs to be reconfigured to inputs via software.

13. A PID control loop algorithm shall provide accurate control of sensed variable.
14. For acceptable accuracy, analog to digital converter in MCU shall be 12 bit (minimum) resolution with CPU reading all 12 bits. Conversion shall be a true 12 bits plus sign on all inputs and outputs.
15. MCU units in system shall be connected by a common data base. Permit access to any MCU on data highway from any location. Include full read-write capability from operational and programming standpoint. Total system information shall be available simultaneously to all Supervisory Stations at any point on data highway. All setpoint and programming change requests shall be coordinated with the Facilities operator.
16. Transmit messages to other units on data highway. Messages transmitted shall be positively acknowledged as received or negatively acknowledged as not received. Negative acknowledgements shall immediately force retransmission of message.
17. Provide an RS-232 serial port for local connection to a Lap Top computer or Palm Pilot.
18. Furnish and install room controllers to provide closed loop pressure independent control of all room ventilation and ambient requirements.
19. All room controllers shall include all inputs and control outputs necessary to perform the specified control sequences. Each room controller shall operate as a stand alone unit, performing its specified control responsibilities independently. All input point and control output point databases as well as the control programs shall be stored in non-volatile EEPROM, EPROM and PROM memory, or a minimum of 72-hour battery backup shall be provided.
20. Momentary or extended losses of power shall not change or affect any room controller setpoints or stored data. Upon resumption of power the controller shall resume full normal operation exactly as before without any need for manual intervention. Upon a power failure or operational failure within the controller, the air terminal shall automatically be held its last position. Should HVAC Mechanical Equipment Controller memory be lost for any reason, the user shall have the capability of reloading the HVAC Mechanical Equipment Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.
21. All room controllers shall include the ability to accept and incorporate a dry contact closure input from an auxiliary source into the room control sequence for such purposes as occupied/unoccupied ventilation changeover.

B. Controllers: Field Equipment controller (FEC) series.

1. Stand alone, multi-tasking, multi-user with minimum 16 bit CPU based direct digital controller.
2. Multiple controllers shall communicate on minimum 19.2 K baud data highway.
3. Control Loop Scan Frequency: Less than three seconds.

C. Points:

1. Input Types:
  - a. RTD (1000 ohm platinum).
  - b. Thermistors
  - c. Contact open/closed.
  - d. 4-20 mA.
  - e. 3-15 psi.
  - f. 0-10 V DC.
  - g. Pulse accumulator.
2. Output Types:
  - a. 0-10 V DC.
  - b. Maintained/momentary on/off.
  - c. 4-20 mA.
  - d. 3-15 psi.

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- D. Software: Provide integral software with required control algorithms and alarm routines.
1. Permit programming of MCU database from portable operator terminals, MCU units on network, Supervisory Stations, or via modem.
  2. Each MCU shall perform normal control and energy management routines as defined by the operator.
  3. Normal Control Routines:
    - a. Distributed digital control of system temperature, humidity, pressure and flow.
    - b. Three mode PID (proportional, integral and derivative) control.
    - c. Logging and alarm logic.
    - d. Normal Power restoration sequential restart program.
    - e. Emergency Power sequential start program.
    - f. Non-volatile control strategies.
    - g. High and low limits with alarms for analog input/output points of each controlled variable.
    - h. Adjustable on-off delays.
    - i. Totalization of analog/digital values.
    - j. Pulse totalization.
    - k. Reset of receiver controller setpoints.
    - l. Trend information and storage.
    - m. Equipment Alternation
  4. Energy Management Routines:
    - a. Time of day scheduling.
    - b. Start/stop time optimization.
    - c. Peak demand limiting.
    - d. Economizer control.
    - e. Enthalpy changeover.
    - f. Event initiated programs.
    - g. Lighting Control Time based occupied/unoccupied modes
  5. Execute temperature control functions within unit. Execute loop control via direct digital control algorithms. Allow user to customize control strategies, sequences of control, define control loop algorithms and choose optimum loop parameters for loop control. Control loops shall support full proportional, integral and derivative control applications.
  6. Permit creation, modification or removal of control algorithms within a MCU, while operating and performing other control functions. Each control loop shall be user definable in terms of:
    - a. Sensors/actuators as part of control strategy.
    - b. Control mode.
    - c. Gain.
    - d. Control action.
    - e. Sampling time.
  7. Permit user to create customized control strategies based upon arithmetic, Boolean or time delay logic. Arithmetic functions shall permit simple relationships between variables (i.e. +, -, /, x) as well as more complex relationships (i.e. square root).
  8. Data Sharing: MCU units shall share appropriate point information such that control sequences or control loops, executed at one unit, receive input signals from appropriate sensors connected to other units within network. When data highway fails or other MCU units malfunction, control loop shall continue to function using last value received from network.
  9. Fail-Safe Operation:
    - a. Provide self diagnostics that continuously monitor operation of unit. Automatically report malfunction of controller, distributed slave module, or associated communication link. Display failure condition with time and date.
    - b. Upon detection of a memory error, each processor shall correct error or halt to prevent erroneous operation. Likewise, upon loss of communication with any

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- controller on the network shall initiate an alarm message. Upon communication being reconnected, a "Return to Normal" message shall be generated.
- c. Upon power restoration after failure, provide automatic sequential restart of equipment based on current program time and program requirements without operator intervention. Provide prioritized restart of systems and equipment as defined on Contract Documents.
  - d. A dedicated fail-safe relay in MCU controller shall change state on a hardware and/or software fault. Relay contacts shall be used to set a fixed fail-safe position for designated output controlled devices.
10. Alarm management:
    - a. Monitor and direct alarm information to operator devices. Each MCU shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network communications traffic, and prevent alarms from being lost. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point.
    - b. Acknowledge alarms from any Station. Printer shall provide time and date of acknowledgment.
    - c. When alarm sent to the existing Supervisory Station is not acknowledged within a selected time, provide dial out alarm message to University supplied phone numbers.
  11. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points documented in control descriptions.
  12. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each MCU point group. Two methods of collection shall be allowed: Either by a pre-defined time interval or upon a pre-defined change of value. Each MCU shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 25,000 data samples.
  13. Trend data shall be stored at the MCU and uploaded to the supervisory station when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers are full. All trend data shall be available for use in 3rd party personal computer software.
  14. MCU shall provide high resolution sampling capability for verification of control loop performance. Operator initiated automatic and manual loop tuning algorithms shall be provided for operator selected PID control loops. Provide ability to view or print trend and tuning reports.
    - a. In automatic mode, controller shall perform a step response test with a minimum one-second resolution, evaluate trend data, calculate new PID gains and input these values into the selected loop.
    - b. For troubleshooting in manual mode, operator shall be able to select variables to override default values. Calculated PID gains shall then be reviewed before they are inserted into the selected loop.
    - c. Loop tuning shall be capable of being initiated either locally at MCU, from a supervisory station or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.
  15. MCU shall automatically accumulate and store run-time hours for all major mechanical equipment (AHU's, EF's, Pumps, etc.).
  16. MCU shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for user-selected site utility monitoring points.

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## 2.06 ELECTRONIC TERMINAL CONTROL UNIT CONTROLLERS (TCU)

### A. Controllers: Field Equipment controller (FEC) series.

1. Furnish TCU units for factory mounting where specified. TCU units shall be connected to the communication network:
2. Controller shall be part of a local area network (LAN) for interface to industry standard air terminal units scheduled.
3. Each TCU shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each TCU shall be a microprocessor-based, multi-tasking, real-time digital control processor.
4. Provide wiring terminals, input/output points, local communication and electrical power.
5. Mount controller, transformer, and differential pressure (flow) transmitter in a dustproof enclosure, and furnish complete assembly to Section 15840 for factory installation. Coordinate left/right hand location with Section 15840 to allow field access to components.
6. Processor shall be minimum 16 bit, with communication rate of 19.2 baud.
7. Input/Output System: Provide required input/output point types necessary to accomplish sequence of operation in Section 15930. Floating point control shall not be permitted for lab or holding room applications. Floating point control shall not be permitted for office area applications unless the manufacturer provides hardware and documentation that clearly states that the airflow rates will not change during the re-calibration or resync cycle. This documentation must be submitted with the shop drawing submittal. For constant volume airflow applications, an industry standard 0-10V or 4-20mA proportional, analog output signal is preferred.
8. Control algorithms shall be programmed for specific application with software modification capabilities.
9. Assign and change set points and control parameters using portable operators terminal or through manual commands at the Supervisory Stations.
10. Use EEPROM to store set points and control parameters (no battery back-up required).

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Verify that systems are ready to receive work.
- B. Beginning of installation means installer accepts existing conditions.

### 3.02 INSTALLATION, GENERAL

- A. Mount MCU controllers and Field Equipment Panels (FEP) adjacent to associated equipment on vibration free walls or freestanding angle iron supports. Do not mount on AHU housing. Coordinate with locations shown on Duct Drawings. Provide, one MCU for each pair of supply fans system. Manifolde exhaust fans shall be monitored/controlled from one controller. Provide nameplates for instruments and controls inside and identify associated system on face of cabinet. Provide mechanically fastened cabinet nameplates in accordance with Section 15075, using nomenclature shown on submittal Flow Drawings. Mount a laminated copy of panel of As-Built drawing(s) inside each cabinet.
- B. Start-up and tune each air handling unit, supply fans and exhaust fan control loop. Verify communication to controllers from Supervisory Stations.
- C. For each system, control system manufacturer shall demonstrate system performance and stability to University prior to final acceptance of system. Manufacturer shall demonstrate that all control sequences function as specified and the performance of each control loop is within



specified limits. Record and print graphical trends for each control loop to verify loop stability is within specified performance limits. Each trend shall be for duration of no less than 12 hours.

PARAMETER	MAXIMUM ACCEPTABLE DEVIATION FROM SET POINT
Duct Static Pressure	Plus or minus 0.03 inches of water
Space Temperature	Plus or minus 2 degrees F
Air Flow	Plus or minus 5 percent

- D. Duct Penetrations: Where instruments penetrate ductwork, provide gaskets, flanges and apply sealant to make opening air tight.

### 3.03 INSTALLATION AND OPERATIONAL VERIFICATION TEST PROCEDURES

- A. Provide system start-up under provisions of Sections 01010 and 01400.

B. General Requirements:

1. Intent of acceptance test procedure is to demonstrate that exact functions of control systems meet requirements outlined by approved shop drawings and written Sequence of Operation.
2. Verify each air handling unit, equipment system, steam and hydronic system in automatic mode of operation, utilizing actual field devices and final control elements. Tune each control loop to allow for desired control action and satisfactory operation of process.
3. Indicate type and cause of failures, as well as required remedial actions, on test report. Start-up and testing will be witnessed and verified by University. Requested tests, not outlined herein, will be evaluated for feasibility and impact on schedule and cost.
4. Systems will not be accepted by University and A/E without approval of tests and required remedial action.
5. Provide signed verification reports to the University for each system tested.

C. Control System Static Check:

1. Prior to static check of system, identify each MCU by description, tag number, and address. Verify proper system communication with these devices, as well as values indicated.
2. Operational static check shall include verification of field wiring associated with appropriate MCU panels. Include continuity testing between wiring from field device (sensor, actuator, or other components) to appropriate block on terminal strip in appropriate enclosure. Verify control loop wiring diagrams and panel wiring diagrams for the following.
  - a. Digital Inputs: Energize each digital input (smoke detector, end switch, control relay, flow switch, differential pressure switch, or other components) in field. Verify at panel.
  - b. Digital Outputs: Force on each digital output (solenoid valve, motor starter, control relay, or other components) at control panel. Field verify corresponding final element for proper stroke/status.
  - c. Analog Inputs: Compare field reading of each analog input (transmitters, thermistor, or other components) with that displayed on graphic screens, and auxiliary panel.
  - d. Analog Outputs: Force each analog output (I/P) to values of 0 percent, 25 percent, 50 percent, 75 percent and 100 percent. Field verify corresponding final element (valve or damper) positions from fully closed to open, based upon stated spring range.

D. Control System Dynamic Check:

1. Operational dynamic check shall include verification that control system, including sensors and actuators, performs as specified, while interconnected to process. Verify proper

system communication with controllers and ability to reset setpoints remotely from Supervisory Stations.

2. Check by operating each air handling unit, equipment system, steam and hydronic system in automatic, and selecting appropriate start/stop functions. Confirm modifiable operator parameters by performing operation and verifying change in status at appropriate supervisory station.
  3. Test system fail, manual start, and power up sequence for air handling units. Verify warnings and fail to start logic. Simulate power failure and restart software for controlled equipment and systems.
  4. Verify and demonstrate that supervisory station interface graphic screens are displayed consistent with Drawings. Verify that status of each digital and analog value on every graphic screen is consistent with expected color convention and actual field device reading. Use only graphic screens acceptable to University.
  5. Test each control loop display to verify that it indicates proper percent of scale and correct scaling of engineering units. Verify loop status by placing loops in AUTOMATIC and MANUAL and ensuring that proper text display appears.
- E. Alarms: Test each alarm identified in Contract Documents. Verify that control system displays proper indication. Test and verify proper acknowledgement of alarms from supervisory station.
- F. Submit verification test reports indicating operating conditions after detailed check out of systems.

### 3.04 DEMONSTRATION AND INSTRUCTIONS

- A. Provide system demonstration and instructions under provisions of Sections 01400 and 01700.
- B. For each system, demonstrate:
1. Cold start.
  2. Sequence of operation.
  3. Seasonal control.
- C. Provide complete demonstration of equipment or systems requiring seasonal operation, during operating season. Perform multiple demonstrations when required within six months.
- D. Provide factory training for a period of five consecutive days, with each day consisting of 8 instructional hours. Train three University personnel with functional operations of the same systems installed. Include software programming.
- E. Provide an additional five days of training on-site, within one year of University acceptance of BMS installation. Scheduling will be at discretion of University; training days may not be consecutive.
- F. Provide experienced instructor(s) to teach University's personnel operation, adjustment, testing, trouble shooting and maintenance of the system. Include detailed instruction manuals which contain any operations specific to this Project.
- G. Videotape demonstrations and instructional sessions. Provide one copy of each videotape to University.

### 3.05 GRAPHICS CONSTRUCTION

- A. Configure a graphic representation for each unique system. Include interlocked equipment. As a minimum, construct graphics for systems and rooms shown on approved Shop Drawings. Coordinate with University to provide in graphic representation with symbols and form acceptable to University.

B. Identify and locate each point on the graphic.

END OF SECTION