

## ADDENDUM NO. 3

For

Owner: University of Colorado at Boulder

Project Name: PR003039 ECCH – HVAC Mechanical Upgrades, Phase 1 of 2

CRA#: 2007-213

Date: March 9, 2009

ENGINEER:

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### **General Information:**

- 3.1 Is there a spec section 15971? **Response: See attached section 15950.**
- 3.2 Spec section 15975 call for pneumatic control interlocks, additional information is needed. **Response: See attached section 15950.**
- 3.3 Are the existing terminal boxes to be converted to DDC? If yes, what is the construction sequence priority? **Response: No, only the new terminal boxes will be DDC.**
- 3.4 Where does electrical power originate to serve the Phoenix valves and the new DDC controllers? **Response: Coordinate locations with UCB HVAC Shop.**
- 3.5 Where does the Andover Infinet communication wiring connect to the existing building? Is the existing system of adequate size to handle these additional controllers? **Response: Coordinate location with UCB HVAC Shop.**
- 3.6 M2.04 RM 153 The 20/10 Transfer grill as drawn will go thru a glass window. **Response: Transfer shall be above window.**
- 3.7 M2.04 RM 157 The 24/14 transfer grill can not be installed where drawn with out moving two existing ducts. **Response: Delete this transfer and increase the 20x10 transfer in Room 153 to 28x14.**
- 3.8 M2.04 Key Note 3 - Provide 12/12 transfer grill in wood pass thru.... – Existing walls are block?? **Response: Use key note number 2.**
- 3.9 M2.04 ROOMS 157, 159, 190, 192, & 194 (these were all I could see in) have lab benches and chemicals, some have sinks and hoods. Are you sure you want to install transfer grills to route return air thru adjacent rooms? **Response: Currently the air is returned into the corridors and we cannot utilize the corridor anymore, so we are creating a new path for the return air.**

### **Specifications**

#### **Section 01210**

- 3.10 Refer to attached Specification Section 01210 – Allowances for information regarding special protection for immovable furniture, fixtures, and equipment. Bidding contractor shall include the contingency allowance in their Bid.

**Section 15950**

3.11 ADD the attached Specification Section 15950 to the project.

**The preceding addendum shall be made a portion of the contract Documents, and each bidder shall acknowledge receipt of the same in submitting bids. All other conditions and requirements of the Contract Documents will remain unchanged.**

**END OF ADDENDUM NO. 3**

Attachment: Specification Sections 01210 and 15950.

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes administrative and procedural requirements governing allowances.
  - 1. Allowances have been established in lieu of additional requirements for protection of existing immovable furniture, fixtures, and equipment. The cost for protection will be established at a later date when additional information is available from the building users.
- B. Types of allowances include the following:
  - 1. Contingency allowances.

1.3 COORDINATION

- A. Coordinate allowance items with other portions of the Work.

1.4 CONTINGENCY ALLOWANCES

- A. Use the contingency allowance only as directed by the Owner for protection of existing immovable furniture, fixtures, and equipment and only with itemized material, equipment, and labor breakdowns in advance of installation of protections.
- B. Contractor's costs for protections required by the Owner and installed as directed under the contingency allowance are included in the allowance. These costs include delivery, installation, taxes, insurance, equipment rental, removal, and similar costs.
- C. Change Orders authorizing use of funds from the contingency allowance will include Contractor's related costs and reasonable overhead and profit margins.

1.5 ADJUSTMENT OF COST

- A. If the net cost of the allowance is more or less than the specified amount of the allowance, the Contract Sum will be adjusted accordingly by Change Order.
  - 1. The amount of the Change Order will recognize:
    - a. Any changes in handling costs at the site.
    - b. Labor.
    - c. Installation costs.
    - d. Overhead and profit.

2. At Project closeout, credit unused amounts remaining in the contingency allowance to Owner by Change Order.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate installation and removal of protections to ensure Owner's requirements are met that each allowance item is completely integrated and interfaced with related work.

3.2 SCHEDULE OF ALLOWANCES

- A. Allowance No. 1: Contractors shall include a \$12,500.00 contingency allowance for protection of existing immovable furniture, fixtures, and equipment as directed by the Owner. The Owner will provide information to the Contractor for each room requiring special protection. Protection allowance is to be used for installation and removal of special protection for immovable furniture, fixtures, and equipment only. Common protection items defined as foreseeable and customary, such as dust control, floor protection, and cleaning, shall not be considered under the contingency allowance.

END OF SECTION 01210

## SECTION 15950 - CONTROLS

### PART 1 - GENERAL

#### 1.1 RELATED WORK SPECIFIED ELSEWHERE:

General Requirements	Divisions 0 and 1
Mechanical	Division 15
Testing, Balancing, and Adjusting	Section 15990

- A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements bound herewith are a part of these Specifications and shall be used in conjunction with this Division as a part of the Contract Documents. Consult them for further instructions pertaining to this work. Contractors shall be responsible for, and be governed by, all requirements thereunder.
- B. All wiring required for proper operation of the automatic temperature system shall be performed by this Contractor.
- C. The automatic temperature control valves, separable wells for immersion sensors, and taps for flow and pressure instruments shall be provided by the Controls Contractor for installation by the Mechanical Contractor under the Controls Contractor's supervision.
- D. All automatic temperature control dampers shall be provided by the Controls Contractor for installation by the Mechanical Contractor under the Control Contractor's supervision, unless they are components of packaged equipment.
- E. Adjustments of manual balancing devices, as required to obtain design air and/or water flows, shall be by the Balancing Contractor. The Controls Contractor shall provide assistance to the Balancing Contractor with control adjustments as required to obtain design flows by:
1. Providing on-site instruction on the proper interfacing and operation of their equipment
  2. Providing the necessary software for use with the balancer's personal computer for interfacing with their control equipment. Where proprietary equipment/gateways are required, this equipment shall be provided for the Balancing Contractor's use.
- F. Airflow stations are provided and installed by the Mechanical Contractor. The Controls Contractor shall make all necessary connections to the control system.
1. Flow meters and other control devices furnished by other contractors shall have all necessary connections to the control system made by the Controls Contractor.

#### 1.2 SPECIAL CONDITIONS:

- A. The University uses only Andover Controls for all DDC applications.
- B. The University has a fixed-price agreement with Westover Controls for all Andover products. A multiplier (discount) to the current Andover price list is disclosed in an agreement between UCB and Westover. The multiplier to be used for each project shall be published in an addendum.

- C. Currently, there are three approved Controls Contractors allowed to bid on projects utilizing Andover Controls products on the campus:
  - 1. Arkay Services
  - 2. Rocky Mountain Power and Controls, with UCB pre-approval
  - 3. Westover Controls.
- D. These companies competitively bid against each other for the entire controls portion of the project; including design, programming, component purchasing, installation, and startup. The cost of any Andover equipment will be included in their price, along with the cost of all other items for which the Controls Contractor is responsible.
- E. In order to perform programming, the company shall have staff who have been certified by Andover withing the last 3 years.

1.3 SCOPE:

- A. Type of System: The automatic temperature control system shall be Direct Digital Control (DDC/EMCS) with electric and pneumatic components as required.
- B. All digital and analog control loops shall be microprocessor (DDC) controlled with electronic final control elements, unless otherwise shown on the Drawings.\*\*\*\*
- C. All damper and valve actuators, shall be electric, unless specified otherwise. If field conditions appear to require another type of actuator, the University HVAC Shop shall be consulted, through the Engineer, for review and approval.
- D. Coordination: This Contractor shall interface with controls furnished with equipment. Provide additional control devices, interlock relays, and signal conditioners when necessary to accomplish specified sequences.
- E. The system shall include all interlocks, field devices, wiring, piping, hardware, and software required to provide a complete, functional system in accordance with these specifications and drawings.
- F. The Controls Contractor is responsible for layout of control panels, based on the points and the type of controllers depicted in the Contract Documents. The following guidelines shall be used for laying out the panels.

Each system shall be controlled through a dedicated panel or set of panels for all its points, in order to achieve stand alone operation. One panle can be used for several systems only if that panle can handle all the points of each system. If more than one panel is used for a system, the panels shall be installed side-by side.  
Provide at least one spare analog and digital input and output per panel.  
It is the Contractor's responsibility to include in his bid the cost of any additional controllers necessary for a complete job, conforming to specifications.  
The shop drawings submitted for review shall include the layout of each panel for approval by the UCB HVAC Shop before installation.

1.4 WORK INCLUDED:

- A. Furnishing and installing a complete, fully functional control system per this specification and the Construction Documents (drawings, specifications, addenda, etc.).
- B. Pre-assembled control panels.

- C. Actuators, thermostats, sensors, transmitters, thermowells, instrument air compressors, filter/dryers, gauges, and mounting hardware as applicable.
- D. Control valves, dampers, linkages, and mounting hardware.
- E. Construction supervision.
- F. Startup and performance testing.
- G. Demonstration and training.
- H. Warranty.
- I. Demolition:
  - 1. When equipment wiring, piping, pneumatics, tubing, telecommunications, cables etc. are abandoned or disconnected, they must be physically removed and disposed of in a professional manner. In cases where the demo could have an adverse effect, or where the scope of demolition is unclear, consult with Shop technician prior to bid submittal. Approval from HVAC/Controls must be given prior to bid submittal for waiver of demolition.

#### 1.5 DEFINITIONS:

- A. These specifications and drawings require finished work, tested, and ready for operation. Wherever the word "provide" is used, it shall mean "furnish and install complete and ready for use."
- B. "Contractor" shall mean the Controls Contractor performing work under this Division of the Specifications.
- C. Where this specification states work to be performed by the words "shall" or "secure" or other performance functions, it shall be assumed that such work shall be performed by this Contractor unless stated otherwise.
- D. The word "Mechanical" applies to all work specified herein wherever applicable.
- E. The phrase "Architect/Engineer" implies that either may perform the task at hand.
- F. The phrases "University Engineer" or "Owner's Representative" implies an assigned representative from the UCB Facilities Management Department.
- G. The term "UCB HVAC Shop" or "CU HVAC Shop" implies a representative of the HVAC shop of the University of Colorado Boulder.

#### 1.6 DRAWINGS AND SPECIFICATIONS:

- A. The mechanical drawings are diagrammatic in character and do not necessarily indicate every required offset, valve, fitting, etc.
- B. All drawings relating to this structure, together with these specifications, shall be considered in bidding. The drawings and specifications are complementary, and what is called for in either of these shall be as binding as though called for by both. Should any conflict arise between

drawings and specifications, such conflict shall be brought to the attention of the Architect/Engineer for resolution.

- C. Unless otherwise indicated, all equipment and performance data listed is for job site conditions (elevation 5,400 ft.).
- D. Drawings are not to be scaled.

#### 1.7 SUBMITTAL DATA AND SHOP DRAWINGS:

- A. All shop drawings, I/O schedules, point lists, system schematics, sequences of operation, and product data shall be submitted for approval per Division 1, Section 01300.
- B. Contractor agrees that shop drawings and/or submittals processed by the Engineer are not change orders, that the purpose of shop drawings and/or submittals by the Contractor is to inform the Engineer which equipment and material he intends to furnish and install.
- C. Submittal data and shop drawings shall conform to the following requirements:
  - 1. All shop drawings shall be prepared according to the requirements in the most current version of Division 00050 of the University of Colorado at Boulder Construction Standards (Computer - Aided Drafting and Facilities Management Standards). A copy is available upon request. Some of the requirements in this document are listed below.
    - a. Shop drawings shall be developed using the most current version of AutoCAD (Autodesk, Inc.) or a version that is 100% compatible with the current version.
    - b. Specific information shall be added to the title block of each sheet to aid in the UCB archiving/retrieval process for construction documentation. A copy of the specific requirements is available from the Facilities Management CAD Office.
    - c. All final or as-built shop drawings for temperature control will become permanent record documents and shall be prepared on size (36" x 24"). Plain paper and CAD files on a standard digital media (i.e., CD, Disk, Thumbdrive).
    - d. All submittal data shall be bound or in a three-ring hard cover binder as appropriate. All the information shall be indexed and tabbed with reference to the specific section of these specifications. Product data sheets shall be marked with the tag number as indicated on the drawings. All options, ranges, and voltages (which will be provided) shall be clearly indicated on each product data sheet.
  - 2. The format for submittal information shall be as follows:
    - a. Control drawings and building plans shall be CAD-prepared drawings. Drawings that cannot represent the total information on one drawing (i.e., a building plan) shall be noted with appropriate match lines, cross references, and key plans.
      - 1) The control drawing package shall consist of:
        - a) A title sheet listing the project title, and index of all the control drawings and a network schematic showing all DDC Panels and network connections on the project. The network diagram shall indicate all communication devices. The following information shall be provided for each network device:

- b) Location (room number)
  - c) Power source (breaker panel I.D. and breaker number)
  - d) Panel software name and serial number
  - e) Type of controller: The network diagram shall depict the actual connection sequence of the devices, including distances between devices, type of wire used and serial number of controller.
- 2) The second drawing in the control package shall consist of actual installation details, and a damper schedule. The damper schedule shall have entries for: Damper tag, system served, quantity, type (PB, OB), CFM, size, actual pressure drop, quantity of actuators, spring range, damper model number, and, and actuator model number.
  - 3) Subsequent drawings shall depict complete systems (air handler, etc.). The drawing shall show the system schematic, all wiring of the DDC controller, all wiring of field devices, starters, and connections to equipment. Each drawing shall have a bill of materials and a sequence of operation.
  - 4) Floor plans shall depict equipment location, sensor, and panel locations. The duct and space static pressure monitor points shall be shown.
- D. Submittal data and control drawings for all equipment and systems shall be submitted (per Section 01300) to the Engineer for review prior to ordering or fabrication of the equipment. The following information shall be included in these submittals:
1. 30 Days or Less After Notice to Proceed:
    - a. Control damper schedules which include size, cfm, spring range of the actuator, quantity of actuators (dampers), and actual pressure drop for each item.
    - b. Technical specification data sheets of each system component and device which includes all data needed to show compliance with this specification.
  2. 60 Days or Less After Notice to Proceed:
    - a. Control drawings with detailed piping and wiring diagrams; system schematics with controlled/monitored device locations; and connections to all enclosures, panels, and controllers, including a bill of material for all systems. Ladder-type electrical schematic diagrams shall be provided for all interlock wiring with magnetic starters, control relays, safety devices, etc.
    - b. Sequence of operation for all controlled and monitored points for each system. Sequence shall be on same drawing as corresponding system schematic.
    - c. A complete input/output schedule for each DDC panel and dedicated controller including point name (the same name to be used in software), functional description of each point, point type, complete wiring diagram for each point from controller to input or output device, field device type, and location, etc.

- d. Communications cable schematic showing panel and controller locations, controller power source, and all interconnecting data and communication conductors. Arrange the panels in the order in which they will actually be interconnected in the field.
  - e. On control drawings show sensor, panel, and equipment locations by referring to room number. VAV boxes shall be shown indicating room number that has sensor or Smart Stat connected to controller. Also indicate, in a matrix-diagram, each room served by that zone.
  - f. DDC network configuration complete with interconnection diagrams for all peripheral devices, batteries, power supplies, etc.
  - g. A bill of material shall be shown on each drawing. The bill of material shall include the device code used on the controls drawings, description of the product, name of the manufacturer, complete model number, measurement range (if applicable), and quantity.
  - h. Identify the electrical power source for each DDC panel by location (room number), panel designation, and breaker number. Include the identification on the drawing and at the DDC panel itself. (Dedicated Powersource)
  - i. Submittals shall also include a complete test plan and procedures. Test plan shall be coordinated with the (Section 15990) Testing, Adjusting, and Balancing Contractor. The test plan shall delineate the methods of testing and recording the results of the point by point verification and calibration of the hardware and the testing and tuning of the software. The test plan shall include a listing of all hardware points with columns for calibration, test and certification. There shall be a similar record for software.
3. 14- Days Prior to System Demonstration and Acceptance Testing:
- a. Provide software programs and sequences written in the program language and in English.

#### 1.8 PROJECT RECORD DOCUMENTS:

- A. Upon completion of the installation, provide a complete set of record (as-built) drawings on digital media. The content and format of the drawings shall be as described previously.
- B. Prior to Final Completion of the installation, prepare complete Operation and Maintenance manuals. Refer to Division 1, Section 01300, and Division 15, Section 15050, for requirements. Also provide one set of digital media containing all CAD-prepared drawings. The file format shall conform to the requirements in the most current version of Division 00050 of the University of Colorado at Boulder Construction Standards (Computer - Aided Drafting and Facilities Management Standards). A copy is available upon request.
  1. Temperature control diagrams including an explanation of the control sequence of each system along with the following instruction wherever applicable.
    - a. Emergency procedures for fire or failure of major equipment.
    - b. Normal starting, operating and shutdown.

2. A reduced copy of the controller drawing, listing all input and output points with functional description's, shall be placed inside the door to each controller enclosure in a plastic pocket attached to the door. The sheet shall be laminated. One sheet is required for each controller housed in the enclosure.

#### 1.9 DEMONSTRATION AND TRAINING:

- A. This Contractor shall provide a minimum of 4 hours of system and control demonstration time at the job site for the Owner's personnel.
- B. This Contractor shall provide at least 4 hours of classroom training sessions at times and location as directed by the Owner. The training shall focus on design, operation, and maintenance procedures of the products installed.
- C. The instructor(s) for the above sessions shall be employee(s) of the Control Contractor whose primary function is customer training and applications support.
- D. A minimum of two copies of the most current control drawings shall be provided to the UCB HVAC Shop before the training begins. These shall be in addition to the drawings to be provided under Paragraph 1.08, if the O&M Manuals have not been turned in to the Engineer before the time of the training.
- E. The training may be phased. The Owner may elect to conduct training and demonstration in two- to four-hour sessions over the life of the warranty period. All instructional material shall be available to each employee at each training session up to a maximum of ten (10) individuals.
- F. All demonstration and training sessions shall be coordinated with the University HVAC supervisor.

#### 1.10 WARRANTY:

- A. The warranty period shall begin as authorized by the Owner's representative in writing. Authorization will not be given before the following conditions are met. Under no conditions will the Controls Warranty begin before the starting date of the General Warranty for the overall project.
  1. Completion of the tests required in Paragraph 3.09 and correction of all problems discovered during the testing process.
  2. Completion of all punch list items that are the direct responsibility of the Controls Contractor.
  3. Conduction of a preliminary training session for personnel of the HVAC Shop of the Department of Facilities Management. The training shall consist of an orientation session at the job site to familiarize the personnel with the location and type of controlled equipment and controls on the project, a discussion of the control sequences, and a review of the control drawings. A copy of the as-built control drawings shall be provided to the HVAC Shop at this time as well. Other, more detailed, training sessions (such as for review of the control programs) may be held at a later date during the warranty period
  4. Completion and distribution of the as-built control drawings, including correction of all items noted by the Owner and Engineer after review of the documents.

- B. The control system shall be guaranteed to be free from original defects in material and workmanship and in software design and operation for a period of one year after completion of the contract. The Contractor shall provide the necessary skills, labor, and parts to assure that all system and component failures are promptly repaired.
- C. The Contractor shall receive calls during the warranty period for all problems or questions experienced in the operation of the installed equipment and shall take steps to correct any deficiencies that may exist. The response time to critical problems shall be four (4) hours maximum.
- D. During the warranty period, the Contractor shall maintain a backup of all software installed in the system. The backup shall be updated monthly or whenever the Contractor makes a change to the software. A reload of backup software into the system shall be performed by the Contractor immediately upon notification by the Owner. The reload shall be free of charge.
- E. The Contractor shall optimize all control software and tune all PID loops to assure acceptable operating and space conditions and peak energy efficiency. This shall include changes needed to optimize operation of the systems even if not explicitly described in Control Strategies.
- F. The Contractor shall include the extended warranty for upgrades of ethernet controllers installed in the building for the warranty year.
- G. At the end of the warranty period, the Contractor shall supply updated copies of the latest versions of all project record documentation as described in Paragraph 1.08, Project Record Documents. This includes final updated drawings, software documentation, and electronic media backups that include all changes that have been made to the system during the warranty period.
- H. Coordinate with UCB BAS administrator or, if unavailable, the UCB HVAC Shop in advance before connecting new DDC control system to campus network.
- I. Once the building DDC is connected to the network, the Contractor shall notify a representative of the UCB HVAC Shop before and after performing any work on the DDC components, and report any changes made.
- J. During the warranty period, University personnel shall make a reasonable effort to determine if a problem is due to the control system or some other source not the responsibility of the Controls Contractor, before requesting warranty service. However, if the Controls Contractor is called out and determines that the problem is not due to the controls system or other building components, the Contractor shall not charge the University for a service call if it is determined that the source of the problem is not his responsibility.

#### 1.11 QUALITY ASSURANCE:

- A. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner's representative in writing. This requirement is not intended to restrict the Contractor to the use of outdated equipment.
- B. All products used in this installation shall be new and currently under manufacture. Spare parts shall be available for at least ten (10) years after completion of this contract.
- C. All DDC components shall be compatible with the rest of the DDC network at the beginning of the warranty period.

#### 1.12 OWNERSHIP OF PROPRIETARY MATERIAL:

- A. All project developed hardware and software shall become the property of the Owner. These include but are not limited to:
  - 1. Project graphic images,
  - 2. Record drawings,
  - 3. Project database,
  - 4. Job-specific application programming code,
  - 5. All other documentation.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS:

- A. Regardless of the manufacturer, the specific products and design chosen shall meet the requirements of this specification.
- B. Use the manufacturers listed below or in the description of the devices:
  - 1. Control Wiring
    - a. TVSS surge protectors
      - 1) Leviton 51010WM or Kelle HSP-121BT IRU or pre-approved equal.
    - b. Ininet Communication Wiring
      - 1) Windy City, Belden or equal: 24 gauge stranded, single twisted pair, shielded, low capacitance (less than 12.5 pico-farads/ft), 78% velocity of propagation.
  - 2. Control Valves
    - a. Steam Valves
      - 1) Steam; Globe Style; AHU Coils.
        - a) 1" - 2" Size; Powers 591/593 Series.
        - b) 2 ½"- 4" Size; Powers 591/593 Series, Fisher Easy-E series, Leslie Class DLOS-2.
    - b. Smart Steam Valves (for Mains): Keystone valves with Peaktronics DHC-100 series.
  - 3. Control Dampers
    - a. Motorized

- 1) Johnson, Ruskin, or Pre-Approved Equal.
  - b. Outdoor and/or return air mixing dampers and face-and-bypass (F&BP) dampers
    - 1) Ruskin CD 403 type or pre-approved equal.
  - c. Shaft bearings
    - 1) Oilite or pre-approved equal.
  - d. Local Control Panels
    - 1) Kele RET Series (color: orange)
    - 2) Panel locks utilize standard 2050 keyed locks
  - e. Compressed Air Supply – Pneumatic
    - 1) Air Compressor
      - a) Electro-Pneumatic (EP) Solenoid Air Valves
        1. Johnson, Honeywell, or Asco.
      - b) Current-Pneumatic (I/P) and Pneumatic-Current (P/I) Transducers
        1. MAMAC EP 313, Johnson- 0-20psi, or UCB Pre-Approved Equivalent
  - f. Solid-State Sensing Devices
    - 1) Room Thermostats
      - a) Andover Smart Sensors for DDC applications, will be LCD Type.
  - g. Transmitters - Solid State
    - 1) Water, Compressed Air, Steam pressure transmitters
      - a) See 2.11 B [3.]
    - 2) Air differential static pressure transmitters
      - a) Air Monitor, Dwyer, or pre-approved equal
      - b) For critical applications
        1. See 2.11 B 7
    - 3) Air differential pressure transmitters
      - a) Dwyer Magnehelic Series 605 or pre-approved equal
4. Auxiliary Devices – Electric

- a. Flow-proving or equipment-operating-status switches
  - 1) Penn, Mcdonald Miller, Flotect V-6 or pre-approved equal.
    - a) Damper end switches
      - 1. Kele & associates TS-470
    - b) Current Sensors:
      - 1. Split Core (clamp on) Neilsen-Kuljian or Kele SCS series or SD100 with led or pre-approved equal
    - c) Pressure switch
      - 1. Barksdale, Mercoid series 1000 or pre-approved equal.
- 5. Actuators - Electric (current or voltage only)
  - a. Siemen's
  - b. Belimo, Johnson, or Honeywell
- 6. Safety Controls
  - a. Freezestats
    - 1) Johnson or Penn, model A70HA-1
- 7. Control Device Locations
  - a. Wind-dampening "weatherhead"
    - 1) Air Monitor S.O.A.P. or pre-approved equal (ANDOVER)
    - 2) For indoor, space, static pressure sensors
      - a) Air Monitor S.A.P. or pre-approved equal
- 8. Identification
  - 1) Wire and pneumatic tubing labels
    - a) BRADY or pre-approved equal
- 9. Fiber Optics – Networking
  - a. Translators
    - 1) Andover Infilink, Model I2\_210 series

## 2.2 AIR TUBING AND CONTROL WIRING:

- A. Air tubing shall be either copper (ACR) in exposed areas, or Type FR polyethylene (within conduit). Soft copper is acceptable in concealed areas.
- B. Cables shall be shielded when so recommended by manufacturer. Conductor size shall be in accordance with manufacturer's recommendations subject to specified minimum size. See Part 3 for allowable types.

- C. All insulated wire to be copper conductors, UL labeled for 90°C minimum service.
- D. Raceway for both wiring and pneumatic tubing shall be per Division 16.
- E. The Contractor shall provide and install:
  - 1. TVSS surge protectors for incoming 120 VAC power to all controllers. Surge protectors furnished shall be UL 1449 listed.
  - 2. Transient voltage protection for all twisted pair and coaxial data communication lines between controllers. Provide all required repeaters to assure signal integrity.

### 2.3 CONTROL VALVES:

- A. Shall be two-way or three-way type for two-position or modulating service as scheduled, shown on drawings, or as specified in Sequence of Operation.
- B. Closeoff (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum closeoff pressure ratings:
  - 1. Steam Valves: 150% of operating (inlet) pressure.
- C. Steam Valves:
  - 1. Body and trim materials shall be per manufacturer's recommendations for design conditions and service, except stainless steel seats are required for all applications. Equal percentage ports for modulating service.
  - 2. Sizing Criteria:
    - a. Two-position Service - pressure drop 10 to 20% of inlet psig.
    - b. Modulating Service - 15 psig or less. Pressure drop 80% of inlet psig.
  - 3. Steam valves shall fail normally open or closed as scheduled on plans or as follows:
    - a. Heating coils in air handlers - normally open.

### 2.4 CONTROL DAMPERS

- A. Motorized dampers, unless specified elsewhere, shall be as follows:
  - 1. Damper frames shall be 13 gauge galvanized steel channel or 1/8" extruded aluminum with reinforced corner bracing.
  - 2. Damper blades shall not exceed 8" in width or 48" in length. Blades are to be suitable for medium-velocity performance (2,000 fpm). Blades shall be not less than 16 gauge.
  - 3. Damper shaft bearings shall be as recommended by manufacturer for application.
  - 4. All blade edges and top and bottom of the frame shall be provided with replaceable butyl rubber or neoprene seals. Side seals shall be spring-loaded stainless steel. The blade seals shall provide for a maximum leakage rate of 10 CFM per square foot at 4"

w.c. differential pressure. Pressure drop shall not exceed 0.04" w.c. for airfoil blades, or 0.10"w.c. for regular blades, at a wide open face velocity of 1,500 FPM.

5. Individual damper sections shall not have a single dimension (length or height) greater than 48". Provide a minimum of one damper actuator per section.
  6. Modulating dampers shall provide a linear flow characteristic where possible. Size the dampers to achieve this characteristic.
  7. Dampers shall have exposed linkages.
- B. Control dampers shall be parallel or opposed-blade type as below or as scheduled on drawings.
1. Outdoor and/or return air mixing dampers and face-and-bypass (F&BP) dampers shall be combination parallel/opposed-blade, approximately 57% OB, arranged to direct airstreams towards each other.
  2. Other modulating dampers shall be opposed-blade type.
  3. Two-position shutoff dampers may be parallel or opposed-blade type with blade and side seals.

## 2.5 LOCAL CONTROL PANELS:

- A. Panels shall house the microprocessor, modem, communication interface, all controllers (except those required at VAV boxes), relays, indicators, clocks, switches, pilot lights, override timers, etc., to allow quick access for adjustment and troubleshooting.
- B. Manual switches and indicating devices shall be flush-mounted on panel face.
- C. Internal components shall be securely mounted on removable sub-panels. Each component shall be individually labeled with function and device identification, as shown on control/interlock shop drawings.
- D. Interconnections between internal and face-mounted devices pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL-listed for 600-volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
- E. Provide on/off power switch with over-current protection and a 1-1/2" main air gauge for control pressure sources to each local panel. Provide a 120-volt duplex outlet inside each control panel that houses a DDC controller (except VAV controllers) if there is not an outlet within 5' of the enclosure.
- F. All control panel locks shall conform to the University standard lock for control cabinets. Contractor shall give the keys to the HVAC Shop at completion of training.

## 2.6 ACTUATORS AND POSITIONERS – PNEUMATIC:

- A. Low-pressure pneumatic actuators shall be piston-rolling diaphragm type or diaphragm type.

1. Actuator housings may be molded or die-cast zinc or aluminum. Exception: Actuator housings for control dampers or control valves may be of high impact plastic construction with ambient temperature rating of 50 to 140°F minimum.
  2. Actuator size and spring ranges selected shall be suitable for intended application.
    - a. Damper actuators shall be selected per manufacturer's recommendations to provide sufficient closeoff force and to provide smooth modulating control under design flow and pressure conditions. Furnish a separate actuator for each damper section.
    - b. On sequencing applications, valve and damper actuators shall be sized for a maximum of a 2 p.s.i. shift in nominal spring range with ranges selected to prevent overlap.
- B. Rack-and-pinion type butterfly-valve actuator shall be totally enclosed with no external moving parts. The actuator shall be rack and pinion type, self-draining body with spring-return to provide fail-open or fail-closed action as required. Actuators shall be sized to provide smooth, reliable actuation at all times. Modulating valves shall be complete with positioners by the same manufacturer. Where indicated, position switches by the same manufacturer shall be provided.

## 2.7 AUXILIARY DEVICES – PNEUMATIC:

### A. Room Thermostats:

1. All room thermostats shall be high-capacity, relay type, with pneumatic feed-back, adjustable sensitivity (1 to 4 psi°F minimum), and an output test port. Provide indicating set point, locking covers (Allen-head screws, or other means), as noted on drawings.
2. Provide single temperature thermostats for heating-only or cooling-only applications, direct-or reverse-acting with range as required.
3. Deadband thermostats are not acceptable. For heating/cooling applications, utilize non-overlapping spring ranges on the heating/cooling devices to achieve a deadband.
4. Provide recessed, aspirating thermostats or conventional thermostats with locking enclosures/guards for all thermostats located in public areas, such as lobbies, corridors, auditoriums, gyms, pools, theaters, stores, warehouses, garages, classrooms, etc.

### B. Pressure-Electric (PE) Switches:

1. Provide one or two-stage switch action SPDT, DPST, or DPDT, as required by application. Electrically rated for pilot duty service (125 VA minimum), and/or for motor control.
2. Shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1, unless otherwise specified.
3. Furnish permanent indicating gauge on each pneumatic signal line to PE switches.

### C. Electro-Pneumatic (EP) Solenoid Air Valves:

1. Shall be snap-acting, three-way air valve with three ports (common, N.O. and N.C.), UL-listed.
  2. Provide diecast or plastic body with stainless steel trim. Minimum safe pressure shall be 30 psig at 130°F ambient and 130°F control air temperatures.
  3. Coil voltage as required up to 120VAC
  4. Provide open type (panel-mounted) or enclosed type for remote installation. Enclosed in type NEMA 1 unless otherwise specified.
- D. Current-Pneumatic (I/P) and Pneumatic-Current (P/I) Transducers:
1. Shall accept industry standard inputs and provide standardized outputs.
    - a. Pneumatic signals: 0-20 psig.
    - b. Electric signals: 4 to 20 mA
  2. Span (calibration) and start point shall be fully adjustable.
- E. Indicating Gauges and Test Ports:
1. Control-signal indicating and test gauges shall be 1-1/2", back-connected, 0 to 30 psig.
  2. Test ports on the air lines connected to a differential air pressure sensor shall consist of a tee in the line with a removable cap on the branch port. Test ports on water lines connected to a differential pressure sensor shall consist of a 1/4" size, quick-connect type, quick disconnect on a branch line with a shutoff valve.
  3. Permanent indicating gauges shall be furnished for all pneumatic transducer, EP, controllers and relay outputs used to position actuators, valves or PE switches. Gauges shall be in local control panels when applicable. One main (supply) air pressure gauge shall be installed in each local control panel.
- F. VAV Box Controls:
1. Electric VAV box controls shall be configured to meet the specified sequence of operation. All hardware necessary to meet the sequence of operation shall be provided. Coordinate with supplier of VAV box. (No pneumatic)
  2. The Controls Contractor shall check, calibrate and setup all VAV box controllers, and be responsible for their operation. This applies whether the controls are provided by the Mechanical Contractor as part of the VAV box or the Temperature Controls Contractor.
  3. Provide assistance to the Test and Balance Contractor in making adjustments to the controls.
  4. See VAV box specifications for controller information.

## 2.8 CONTROL DEVICES – ELECTRIC:

- A. Room Thermostats:

1. All wall-mounted, room thermostats or sensors shall have locking covers with concealed set point adjustment. Omit thermometers when possible.
2. Line-voltage thermostats shall be UL-listed, SPDT, SPST, or DPST with contact rating suitable for application, maximum 2°F differential.
3. Low-voltage thermostats shall be single or multi-stage heating and/or cooling type as required by application.
  - a. Combination heating/cooling thermostats shall have independent adjustments for heating and cooling setpoints and shall not allow setpoint cross-over.
  - b. Provide individual heat or cooling anticipator for each control stage. Anticipator shall be matched to connected load, or shall be adjustable.
  - c. Microprocessor-based programmable type thermostats, when used, shall not lose time or program on power failures of 12 hours or less.
4. Provide locking enclosures/guards for all thermostats located in public areas such as lobbies, corridors, classrooms, etc.

#### 2.9 SOLID-STATE SENSING DEVICES:

- A. Space (room) sensors shall be surface-mounted. Space sensors shall have an exposed sensing bead mounted behind a suitable protective enclosure. Sensors mounted to the back of a blank junction-box cover are not acceptable.

#### 2.10 TRANSMITTERS - SOLID STATE:

- A. Transmitters shall have sensing elements suitable for the application.
  1. Provide averaging elements for mixed and discharge-air temperature applications.
- B. Transmitters shall have direct-acting, linear output signal compatible with controller, with full scale accuracy of  $\pm 1\%$  or better. Zero and span shall be field-adjustable.
  1. Transmitter sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage. Air pressure transmitters shall have a minimum overpressure rating of 10" W.C.
  2. Air differential static pressure transmitters: [Note to Consultant: For critical applications where the differential pressure can drop below 0.2" W.C. - such as outside-air flowrate monitoring, or critical differential pressure control applications in laboratories - specify an Air-Monitor, Veltron II Model, differential-pressure transmitter only.]
  3. All differential pressure transmitters for air shall have panel-mounted differential pressure gauges. Provide tees with removable caps on the high- and low-pressure lines.
- C. Transmitter Span Selection:

1. The span of each transmitter must be carefully selected by the Contractor. Typical spans are shown above in Section 2.11 B. General selection procedures are given below.
2. The selection of the appropriate transmitter span is a crucial step in the design of a functional control system. In general, the span of the transmitter should match the normal ranges of the variable to be controlled. For example, the measurement of system pressure where the normal operating pressure is 20 psi and the peak system pressure is 35 psi, the correct span selection would be 0 to 50 psi. A 0 to 100 psi span, while workable, would be operating in the lower third of the span under normal conditions. This decreases the controller's ability to detect small changes in pressure. Ideally, the control setpoint should be at approximately 75% of the transmitter's span. However, expected maximum and minimum values encountered during normal operation of the system must be accounted for.
3. Particular attention to transmitter span must be taken with airflow monitoring stations. The recommendations of the airflow-monitoring station supplier must be followed. Be sure to include an altitude correction factor.
4. Transmitters found operating in the lower 33% or upper 20% of their span, during normal conditions of system operation, shall be replaced, at the Contractor's expense, with units having an acceptable span.

#### 2.11 AUXILIARY DEVICES – ELECTRIC:

- A. Flow-proving or equipment-operating-status switches shall be paddle, differential-pressure, or current-sensing types as indicated below.
  1. Differential-pressure-type switches (air) shall be UL-listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application, or as specified.
  2. Current-sensing-type sensor shall be used to prove equipment operation in those applications. Current-operated switches shall be self-powered, solid state clamp on with adjustable trip current and led. The switches shall be selected to match the current of the application.
- B. Damper end-switches shall be UL-listed, line voltage SPDT snap-acting, pilot duty rated (125 VA minimum)
- C. Control relays shall be UL-listed, plug-in type with dust cover and an "energized" indication light. Contact rating, configuration, and coil voltage suitable for application. Provide diodes to limit back EMF on all DC relays and MOVs on AC. IDEC, or approved equal.
- D. Time-delay relays shall be UL-listed, solid-state, plug-in type with adjustable time delay. Delay shall be adjustable plus or minus 200% (minimum) from setpoint shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.
- E. Control transformers shall be UL-listed, Class 2 current-limiting type, or shall be furnished with overcurrent protection in both primary and secondary circuits for Class 2 service.
- F. Manual control switches shall be UL-listed for use in NEMA 1 enclosures with contact arrangement and rating suitable for application. Bat handle or knob actuator with nameplate clearly identifying function of each switch position.

- G. Override timers shall be spring-wound, line-voltage, UL-listed, with a contact rating and configuration as required by the application. Provide 0 to 6-hour calibrated dial unless otherwise specified; suitable for flush mounting on control panel face, located on local control panels or where shown on plans. Timers shall not be provided with a hold or override feature.

#### 2.12 ACTUATORS – ELECTRIC:

- A. Electric actuators are acceptable. HVAC Shop will pre-approve.
- B. Actuator size and rating shall be suitable for intended application.
  - 1. Damper actuators shall be selected per manufacturer's recommendations to provide sufficient close-off force to effectively seal damper. Modulating actuators shall provide smooth modulating control under design flow and pressure conditions.
  - 2. Valve actuators shall provide tight close-off at design system pressure. Modulating actuators shall provide smooth modulation at design flow and pressure conditions.
  - 3. Provide feedback transmitters and/or end switches where specified.
  - 4. Actuators shall be specified per the Control Sequences section. Actuators relying on batteries are not acceptable.

### PART 3 - EXECUTION

#### 3.1 CONTROL-AIR PIPING:

- A. All control-air piping shall be concealed, except in equipment rooms or unfinished areas. Installation methods/materials as follows:
  - 1. Concealed and Inaccessible: Copper tubing (type ACR) without joints or FR plastic without joints in metal conduit. Exceptions: Room thermostat drops in stud walls may be FR plastic tubing in areas with lay-in ceiling. Lines encased in concrete must be in metal conduit, and their location must be shown on as-built control drawings.
  - 2. Concealed and Accessible (including ceiling return air plenums): Same as for concealed and inaccessible, except the air lines may have joints.
  - 3. Exposed: Hard-drawn ACR copper or FR plastic in metal raceway, installed parallel to building lines. All joints shall be brazed.
  - 4. Final Connections:
    - a. Where copper tubing is used, a short section of FR plastic tubing (18" long maximum) is acceptable at final connection to control device. However, copper-to-barb fittings shall be used at junctions; plastic slipped over copper tubing is not acceptable.
  - 5. Pneumatic tubing may be run in conduit containing electrical wiring as long as conduit size meets electrical code for capacity.
  - 6. Where pneumatic tubing exits control panels, provide bulkhead fittings. Where copper tubing exits junction boxes or panels, provide bulkhead fittings.

- B. All control-air piping shall be installed in a neat and workmanlike manner parallel to building lines, with adequate support. Piping above suspended ceilings shall be supported from or anchored to structural members or other piping **and/or** duct supports. Tubing shall not be supported by or anchored to electrical conduits.
- C. Pressure-test main control-air piping to 30 psi for 24 hours prior to connection to control devices. Test fails if there is a loss of more than 5 psi. The pressure test shall be witnessed by the Owner's Representative or Engineer. Provide pressure-test certification to the Engineer.

### 3.2 CONTROL WIRING:

- A. All control and interlock wiring shall comply with the national and local electrical codes.
- B. All Class 1 (line voltage) wiring shall be UL-listed in approved raceway per NEC.
- C. All low-voltage wiring shall also be in conduit. Conduit type, sizing, and installation requirements shall conform to NEC.
- D. All cable conductors shall be minimum 18 AWG TFFN stranded. Cables shall be shielded when so recommended by the manufacturer. Line-voltage power and interlock wiring conductors shall be sized in accordance with NEC.
- E. All wire insulation shall be color-coded and labeled for ease of identification.
- F. All control wiring shall be installed in a neat and workmanlike manner parallel to building lines, with adequate support. Install without splices.
- G. This Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- H. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, liquid-tight, flexible metal conduits shall be used.
- I. Low-voltage (24V or less) AC or DC wiring shall not be run in conduit containing 120 VAC wiring.
- J. Infinet Communication Wiring:
  - 1. Splicing is not acceptable.
  - 2. Label all junction boxes. Labels provided by the UCB HVAC Shop
- K. Label all temperature control wiring and pneumatic tubing junction box covers with an adhesive backed water proof flexible mylar label with the letters T/C using an orange background with black letters to differentiate them from junction boxes installed by the electrical and fire alarm contractor. The labels shall be 3" by 3".
- L. Use proper size wire nut type connectors on all sensor wiring. Crimp connectors are not allowed on sensor wiring.

### 3.3 ANDOVER CONTROLLERS:

A. NET CONTROLLERS

1. The Controls contractor shall follow the specifications shown in the Andover Hardware Installation Guide unless stated otherwise herein.
2. All Andover DDC controllers shall be connected to the existing university Andover network.
3. Operating Andover controllers that are not connected to the university Andover network shall not be accepted.
4. Andover net controllers shall be installed in a KELE RET2826 OR, RET4230 OR cabinet.
5. Install Minimum 650VA UPS in Separate Panel to feed net Controller.

B. SCX 920 LCX 810, TCX 850, LCX 800I (all infinity controllers)

1. The Controls contractor shall follow the specifications shown in the Andover Hardware Installation Guide unless stated otherwise herein.
2. Controller Power shall have a separate disconnect (or fuse) for each controller.
3. All controllers will be connected for 24VAC, or 120V.
4. All digital outputs will have a relay to operate the device
5. Only Two pair of communication wires shall be connected to the communication terminal on the controller.

C. Expansion Modules: Andover DDC

1. The Controls contractor shall follow the specifications shown in the Andover Hardware Installation Guide unless stated otherwise herein.
2. The use of Andover DCC expansion Modules shall be pre-approved by the University HVAC Shop.
3. Expansion modules can be used only with authorizations from HVAC shop.

D. Infilinks Installation

1. The Controls contractor shall follow the specifications shown in the Andover Hardware Installation Guide unless stated otherwise herein.
2. Use an Infilink I2200 to connect controllers in a building together.
3. Use an Infilink I2210 to connect controllers between buildings.
4. When Infilink I2210s are required, Controls Contractor shall supply two Infilinks.
5. To series Infilinks together communication wires shall be connected to Port 1.
6. Only 2 pair on port 1.

7. Only 1 pair on ports 2-5

### 3.4 INSTALLATION AND SETUP REQUIREMENTS:

#### A. Metal Oxide Varistors (MOV) on Outputs:

1. Install MOVs across all inductive loads being switched by an output from an Andover controller. This includes all relay coils, solenoid coils (E/Ps), etc. Install the MOV across the coil of the device. Use an MOV rated for the voltage of the coil.

#### B. Grounding the Shield on Communication Wiring:

1. The shield on communication wiring should be grounded in only one location per building. The connection point for the shield wire on LCX and SCX panels is not grounded. Connect the shield to this terminal on each panel just for consistency. The standard grounding location for each building shall be at the Infilink (see 3.03, C).
2. Tap any exposed shield wiring so that it cannot short-out on the Infilink housing or other source.

#### C. Splices in Communication Wiring:

1. Not allowed.

#### D. Standard Nomenclature for Valve and Damper Position Description:

1. Set up the conversion table for each valve or damper control output so that 100% OPEN = open and 0% OPEN = closed.
2. For mixed-air dampers, 100% OPEN = fully open outside air damper and closed return damper.

#### E. Setup of Setpoints

1. The Setpoint Box in the CX and Cyberstation software shall be checked for all numerical points to be used as setpoints or any type of constant value point.

#### F. Setup of Inputs

1. THRESHOLDS: The threshold shall be filled-in with the following value. Where a particular application is not listed, enter a reasonable value based on the application.

Temperature (Space, OAT, MAT, DAT, RAT, etc.) .1°F  
Space Static Pressure 0.01"W.C.  
Duct Static Pressure 0.2W.C.  
Relative Humidity (Space, OAT, MAT, DAT, RAT, etc.) 1%

#### G. Provide thermal-conducting compound for all sensors in thermowells.

#### H. Protect all points where pneumatic tubing or sensing elements come in contact with metallic surfaces by enclosing the tubing or sensor with a section of poly-tubing. This applies at such locations as duct penetrations, points where tubing is attached to ductwork, points where sensing elements come into contact with or are attached to coil frames, etc.

- I. Seal all penetrations into ductwork or air-handling units with duct sealant or other means to make the installation airtight.
- J. Mount all control valves so that the stem is vertical. Prior approval is required from the UCB HVAC Shop for all installations where this cannot be achieved.
- K. Averaging-type sensing elements shall be firmly supported in ductwork or air-handling units using 1/2" EMT or other auxiliary support.
- L. Layout of Points on Controllers: The points on controllers shall be coordinated for approval by the UCB HVAC Shop.

### 3.5 CONTROL DEVICE LOCATIONS:

- A. Room thermostats and sensors shall be mounted 5'-0" above finished floor unless otherwise noted on drawings.
- B. Provide wind-dampening "weatherhead", with insect screen on outdoor-atmospheric-pressure-sensing point and mount at least 3' above the highest roof structure to minimize false readings due to wind direction and/or eddies.
- C. Remote control devices not in local panels shall be accessible for adjustment and service - below 6' above finished floor whenever possible.

### 3.6 CONTROL PANELS:

- A. Refer to Part 2 - Products for construction details.
- B. Field wiring shall be in conduit.
- C. Panels shall be wall-mounted at eye level for accessibility and service.
- D. Local control panels shall be located within same room of system served otherwise location shall be approved by UCB HVAC Shop.
- E. Control devices shall be installed in panels. Electro pneumatic switches (EPs) and relays shall be grouped together and installed in a single, central panel located next to the enclosure housing the associated controller. Remotely-mounted relays and EPs are not acceptable and PE switches are allowed unless preapproved by HVAC Shop.
- F. Electrical power for each panel shall be from a dedicated circuit. For retrofit applications, where connecting to existing control-power wiring, it is Contractor's responsibility to verify that the power source is from a dedicated circuit. Side-by-side panels may be served by the same circuit, with separate disconnect for each panel. Notify the Owner if the source is not from a dedicated circuit. Where available in a building, utilize emergency-power circuits for all controls.
- G. Mount panels on solid, non-vibrating surfaces. Where such surfaces are not readily accessible, mount the panel on a rigid, Unistrut stand attached to the floor. The sides of ducts and air-handling units are not acceptable mounting surfaces.

### 3.7 IDENTIFICATION:

- A. All control equipment shall be clearly identified by HVAC shop drawing designation code and a functional description as follows:

1. Control valves: brass tags.
2. Other remote control devices and sensors: metal tags; plastic laminate labels; or, on non-porous surfaces only, permanent label tape as produced by the Brother "Easy Touch" label maker. Do not attach tag or label to removable covers, etc. Rivet or stick to device or adjacent surface.
3. Control panels: nameplate with panel number and systems served.
4. Devices in control panels: engraved plastic tags; metal tags; or, on non-porous surfaces only, permanent label tape as above, mounted to panel adjacent to control device.
5. All wiring, including wiring within factory-fabricated panels, shall be labeled within 2" of each termination with DDC point number/controller number or other descriptive information.
6. When connecting DDC controllers, terminating of inputs and outputs shall be color coded as follows:  
  
120VAC shall be black = hot, white = neutral, green = ground  
24VAC shall be (+) black with white tracer, (-) white with black tracer  
24VDC shall be (+) red with black tracer, (-) black with red tracer  
All pneumatic tubing shall be labeled within 2" of termination with a descriptive identifier.
7. All metal and plastic engraved labels shall be secured with chains, nylon tie-wraps, or rivets. Permanent adhesive is acceptable only when mechanical fasteners would damage the labeled equipment.
8. All switches, relays, and panel components shall be labeled.
9. Labels shall not be mounted on removable surfaces, such as cable tray covers.

### 3.8 PROTECTION:

- A. The Contractor shall protect all work and material from damage by his work or workmen, and shall be liable for all damage thus caused.
- B. The Contractor shall be responsible for work and equipment until finally inspected, tested, and accepted. He shall protect work against theft, injury, or damage; and shall carefully store material and equipment received on site which is not immediately installed. He shall close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

### 3.9 CLEANUP:

- A. At the completion of work, all equipment on the project shall be checked and thoroughly cleaned including under equipment and any and all other areas around or in equipment provided under this section. Clean exposed surfaces of all equipment and panels of all grease, plaster, or other foreign material. Remove all stick-on labels and clean surfaces.

- B. At the completion of the work, remove from the building, the premises, and surrounding streets, alleys, etc., all rubbish and debris resulting from this project, and leave all equipment spaces clean and ready for use.
- C. At the completion of work, all equipment furnished under this contract shall be checked for paint damage, and any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet, jacket, or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.10 TESTING:

- A. Prior to substantial completion, the control system shall undergo a series of tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his own performance tests.
- B. The tests described in this section are to be performed in addition to the tests that the Contractor performs as a necessary part of the installation, startup, and debugging process. Control system testing shall be coordinated with the HVAC Shop.
- C. The Contractor shall provide at least two men equipped with two-way communication, and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, summer, winter, occupied, unoccupied, **fire/smoke** alarm, and power failure modes. The purpose is to test the setup, calibration, response, and action of every point. Any test equipment required to prove the proper operation shall be provided by and operated by the Contractor. The Commissioning agent and the Owner's representative shall observe, direct and review these tests on site at controller **panel/field** location.
  - 1. The system software shall be complete such that each control loop shall function as specified in the Sequence of Operation and proper PID tuning. This Subcontractor shall be required to furnish the software program and test the operation of every control loop.
  - 2. After all field connections have been made and control power is available in the control panel, the Owner's representative shall be notified and the control system shall be energized. Any required reloading of the software shall be performed and commissioning of the mechanical system, automatic temperature control system, and other connected systems shall commence.
  - 3. This Subcontractor shall be responsible for all necessary revisions to the software as required to provide a complete and workable system consistent with the letter and intent of the specification. Control performance criteria is specified in the sequence of operations shown on the drawings and/or the specifications.
- D. Operational logs for each system which indicate all setpoints, operating points, **valve/damper** positions, mode, and equipment status shall be submitted to the **Engineer**. These logs shall cover a 24-hour period and have a sample frequency of not more than 10 minutes. The logs shall be provided in printed and digital media formats.
- E. Control loops shall maintain setpoint within the following tolerances:

Air Pressure	$\pm 0.5$ " w.g. $\pm 0.01$ " w.g.	range 0-6" w.g. range -0.1 to 0.1" w.g.
Airflow	$\pm 100$ cfm	

Temperature  $\pm 1.0^{\circ}\text{F}$

Control loops that do not meet the above tolerances shall be re-tuned.

- F. This Contractor shall demonstrate HVAC alarms prior to placing ventilation systems in service.
- G. The control systems will not be accepted as meeting the Requirements of Completion until all tests described in this section have been performed to the satisfaction of both the Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the Completion Requirements if stated as such in writing by the Owner's representative. Such tests shall then be performed as part of the warranty.
- H. After the system has operated properly for 90 days following startup of the final component of the heating and air conditioning systems, as-built copies of the software on electronic media and a printed copy shall be submitted to the Owner for permanent record purposes. Any software upgrading or enhancements to improve the system operation or as required for proper operation of the system during the first year of operation is the responsibility of this Subcontractor. When changes are made to the software, the HVAC Shop must approve. The Contractor shall immediately provide updated copies of the files.

### 3.11 CONTROL EXECUTION – GENERAL:

- A. This Contractor shall provide all required control interface relays, including Control Contactors for single-phase pumps and fans (generally 1/3 hp or less) and any isolation relays required for interface to three-phase magnetic starter control circuits. All power wiring to single-phase motors and three-phase starters by Division 16; all control function (interlock) wiring by the Controls Contractor.
- B. This Contractor shall be responsible for providing control power to all his controllers and devices requiring control power including installation of any required breakers, unless such wiring is shown on the Division 16 drawings.
- C. Accessibility: Install all control devices in readily accessible locations as defined by Chapter 1, Article 100, Part A of the NEC.
- D. Program as follows: Initially set times so as not to exceed six starts per hour. On two-speed motors, provide a 20-second adjustable time delay when transferring from high-speed to low-speed, to allow the load to decelerate.
- E. All setpoints, operating points, sequencing ratios, PID tuning parameters, and all other numeric and digital constants shall be adjustable by the user (only with a high-level password) from the graphic. To change these values, the user shall not be required to modify program code, recompile, or download.
- F. Hand-Off-Auto switches shall energize equipment in both the 'hand' and 'auto' mode (when auto is commanded on for auto mode). Safeties shall protect equipment in the hand and auto modes. Where fans are interlocked with damper end switches, the hand and auto positions shall open the dampers and the damper end switch shall energize the fan.
- G. System logs, trend logs, and event-initiated logs shall be set up to provide historical and real-time monitoring of system operation. Logs shall be grouped by equipment.

- H. Safety Shutdowns - Boilers and Chiller: Boilers and/or chiller will be provided with all required safety controls as specified in Division 15. Safety trip shall shut down respective boiler or chiller directly and shall be annunciated at the Central Work Station.
- I. Safety Shutdowns - General: All safety shutdowns of electrical equipment shall be hardwired. All shutdowns shall occur directly through interconnection of contacts on the safety device with the controlling circuit of the electrical equipment. Safety shutdowns through software are not acceptable. Interposing relays may be used only with prior approval of the Engineer and Owner's Representative when no alternative exists.
- J. This Contractor shall notify the University two weeks in advance of when connection to the BAS network will be beneficial to the system so the work can be scheduled.

### 3.12 WORKSTATION PROGRAMMING:

- A. The University has multiple workstations networked across the campus. The main file server is located in the Facilities HVAC office in the Stadium Building. All graphics, alarms, trend logs, and schedules shall be accessible from any workstation and be fully integrated with existing menus.
- B. Graphics:
  - 1. The system shall be programmed by the Controls Contractor to provide a color graphic for:
    - a. Opening screen graphic showing the building, campus, facility, etc.
    - b. Each HVAC air and water system monitored or controlled
    - c. Each floor and zone controlled (floor plan) - both HVAC and smoke detectors where applicable
    - d. Each VAV box with DDC controls
    - e. Each electrical subsystem monitored or controlled
    - f. Each time-scheduling program
    - g. Utility consumption and outdoor condition logs
    - h. Each miscellaneous monitored or controlled point
  - 2. Menu Penetrations: "Buttons" shall be provided to allow the user to easily move among the various graphics and menus. At any time, the operator shall be able to return to the main menu with one mouse click and shall switch from graphic to other modes within two mouse clicks.
- C. Alarm Setup:
  - 1. UCB personnel shall program all general equipment alarms not specified elsewhere in this section. Alarm programming will begin after the contractor has completed programming for all controllers and the new control system is on-line on the campus Andover network.
  - 2. The contractor shall allow full access to the control system by authorized UCB personnel for the purpose of programming alarms.
- D. Trend Logging:
  - 1. The system shall trend and display numerically and graphically any analog or digital points in the system.

2. Trend logging and historical logging shall be programmed for all points and be fully operational.

3.13 DDC SOFTWARE:

- A. Provide sufficient internal memory for the specified control sequences and logging. There shall be a minimum of 15% of available memory free for future use.

3.14 THIRD PARTY PROTOCOLS:

- A. BacNet – All BacNet connections will require pics and bibs documentation for review by the UCB HVAC Shop. The shop will determine if the protocol meets the needs of the University's objective for each project.
- B. MODBUS – All MODBUS connections will be reviewed by the UCBHVAC Shop. The shop will require a detailed list of X-Driver points to determine if the protocol meets the needs of the University's objective for each project.

3.15 INSTALLATION:

- A. All controllers are to be installed with a minimum clearance of 36" or manufacturer's requirements, whichever is the most restrictive. Variances are permitted only with prior approval.
- B. Identify locations of control transformers in the as-built control drawings, and install labels on the ceiling rid with the designation "CTRL XFMR". Add tag at transformer indication the device it serves.

END OF SECTION