

SECTION 15900

HVAC CONTROLS AND INSTRUMENTATION

PART 1 GENERAL

1.01 SYSTEM DESCRIPTION:

Stanford University has adopted a hybrid approach to building Heating, Ventilation and Air Conditioning (HVAC) controls and automation. This approach utilizes Stanford's campus-wide computer based system for primary building HVAC system control, utility interface control and metering, critical alarm monitoring, and HVAC system scheduling, and either pneumatic or Lon Based Distributed Digital Control (DDC) zone controls for secondary local control purposes.

The computer based Energy Management and Control System (EMCS) provides a common user interface for Facilities Operations technicians and Engineers, and Maintenance Customer Service (MCS) and Operations Services Unit (OSU) operators. Centralized control of main air handling equipment provides the opportunity to remotely manage building utility demand through the common operator interface, quickly modify primary HVAC system set points and control strategies, and achieve energy savings through internally supported system programming. Pneumatic zone controls and actuators or Lon Based DDC zone controls and actuators provide a low first cost solution to the majority of building control requirements without sacrificing energy efficiency and centralized monitoring of critical systems, and with lower long-term maintenance costs through manufacturer interchangeability, documented reliability, and overall simplicity. We believe this approach provides the optimal balance between energy management, reliability, operability, and maintainability that our customers expect.

For building control applications, the campus EMCS is utilized for:

- Steam, chilled water and electrical metering
- Steam and chilled water utility interface control
- Main air handler (>5000 CFM) control (start/stop, economizer, discharge temperature, humidity, static pressure as applicable)
- Hot water generator control
- Secondary chilled water loops including process cooling water system control
- Primary monitoring of life safety systems not connected to the fire alarm system
- Secondary monitoring of the fire alarm panel
- Any process control applications specific to the building

Pneumatic or Lon Based DDC zone controls and actuators are used for the bulk of control needs including:

- Re-heat coils
- VAV boxes
- Fan coils
- Small (<5000 CFM) air handlers

Program requirements for accuracy or monitoring may dictate the use of the EMCS for zone control.

Facilities Operations recognizes that the approach to control systems outlined in this document may not be appropriate for outlying buildings or small renovations where a different approach was used in the past. The HVAC Shop Supervisor, EMCS Shop Supervisor or Facilities Zone Manager can clarify the appropriate control technology for a specific project.

1.02 EMCS DESCRIPTION:

The campus-wide EMCS is an Emerson DeltaV process control system. In addition to building control applications, the EMCS is used for utility production and distribution system control, monitoring and measurement. The EMCS uses distributed controllers (typically one or two per building) and generic instrumentation and output devices available from many manufacturers and vendors. The vast majority of instrumentation used in buildings is commercial grade - the significant exception being instrumentation specified for utility metering and interface control where industrial grade instrumentation is warranted.

The building controllers communicate over a private Ethernet network to data acquisition computers and operator workstations distributed across the campus. The system is monitored 24 hours per day.

The University has a purchasing agreement guaranteeing pricing to protect the University's investment in this system. Facilities Operations procures the building controller for the project and self-performs the programming and program documentation. This ensures:

- All Controls Contractors have the opportunity to bid on work at the University.
- User interface integrity and commonality.

Facilities Operations also participates in building start-up and commissioning. This ensures:

- A thorough understanding of building operations by Facilities personnel prior to building turn over.
- That all mechanical systems are demonstrated to perform as designed prior to building turn over.

1.03 DDC CONTROLS:

DDC controls are to be LonMark certified. Stanford's intent is to have standardized communication protocol with the ultimate goal of achieving component interchangeability with alternate manufacturers within a LON network.

1.04 PNEUMATIC CONTROLS:

Pneumatic controls and actuators using industry standard 3 - 15 psig control air signals are acceptable for use in Stanford Facilities, and may be warranted particularly in renovation projects where pneumatic controls already exist. The Honeywell Serviceline series of controls is the University's preferred choice. Pneumatic controls ensure:

- All Controls Contractors have the opportunity to bid on work at the University
- Timely service and repair including after hour service
- All HVAC technicians can service all HVAC systems
- Technician training requirements are minimized
- Higher technician productivity

A single pneumatic control manufacturer ensures:

- Parts inventory cost is minimized
- Procurement costs are minimized

Honeywell is the University's preferred choice because:

- Proven reliability
- Competitive multi-vendor availability
- Ample local parts availability

1.05 CONTROL CONTRACTOR'S WORK SCOPE

- A. General: The building control computer(s) and interface hardware to the campus EMCS will be provided, programmed and documented by the University. The Controls Contractor shall be responsible for ensuring all other aspects of the complete control system are provided, installed and complete in all respects so as to perform the measurement, monitoring, and control functions specified in the design and construction documents.
- B. Engineering, Supervision, and Documentation: The Controls Contractor shall supply all labor and materials for documentation of provided equipment, job supervision, checkout, start-up, and calibration for all specified equipment and systems, and for training of University personnel on the new equipment provided by the Controls Contractor.
- C. System Testing: The Controls Contractor shall test the complete control system in accordance with Sections 3.09 and 3.10.

1.06 SUBMITTALS

- A. Construction drawings shall be provided for all control system electric, electronic, and pneumatic schematics and wiring diagrams. Drawings shall be submitted for review and approval by the Consultants and the Owner prior to construction. As-built drawings shall be submitted prior to building turn over.
- B. Control Submittals shall be submitted for review and approval by the Consultants and the Owner prior to construction. Control Submittals shall be submitted in an organized manner with the various items indexed and tabulated. Specific equipment to be provided shall be clearly identified in the product literature.
- C. Operations & Maintenance manuals shall be provided and shall be reviewed with the University's appropriate Facilities Operations staff to familiarize them with nomenclature, control devices, system function, troubleshooting methods, and equipment. Manuals shall be submitted in an organized manner with the various items indexed, tabulated, and bound for ease of long term use by the University.

1.07 SERVICE CONDITIONS

. All equipment shall perform as specified under the following conditions:

1. Maximum Dry Bulb / Wet Bulb Temperature: 120/100° F
2. Minimum Dry Bulb / Wet Bulb Temperature: 30/20° F

1.08 WARRANTY

The Controls Contractor shall warrant that all equipment supplied by the Controls Contractor, and all work performed by the Controls Contractor shall be free from defects in workmanship and materials for a period of one year from acceptance by Stanford. If any such products or workmanship should prove to be defective within the one year period, the contractor agrees to correct by either repair or replacement with equivalent product or corrective workmanship, provided that such defects developed under normal and proper use. The equivalency determination rests with the University. Troubleshooting service, preventative maintenance, and scheduled re-calibration of the system is the responsibility of the Owner.

PART 2 PRODUCTS

2.01 DDC CONTROLS:

DDC controls are to be LonMark certified. Stanford's intent is to have standardized communication protocol with the ultimate goal of achieving component interchangeability with alternate manufacturers within a LON network.

2.02 ELECTRIC / ELECTRONIC CONTROLS:

In cases where the campus EMCS or building DDC are not available or appropriate, thermostats shall be supplemented with programmable timers to automatically control start and stop of HVAC equipment. Timers must have the following capabilities:

- Full year (365-day) scheduling (i.e., start/stop times can be programmed for each day of the year, not just each day of the week)
- Standard "user-friendly" program interface
- Multi-program storage capability (e.g., normal, bypass, holiday, etc.)
- Capability for timed by-pass control by occupants on single-room units
- A clock that automatically adjusts for Daylight Savings time and leap years
- Long-life batteries (3-5 years) to back up clock and program memory
- Port for quick and easy program download from portable computer
- Capability for future remote dial-up or Ethernet connection (where applicable)

The *Intermatic ET70215C* electronic time switch is the University's preferred choice.

2.03 PNEUMATIC ZONE CONTROLS, ACTUATORS AND VALVES

- A. Wall mounted thermostats shall be two-pipe thermostats with tamper-proof covers. Locking covers preventing set point access shall be provided in public areas. Standard covers providing set point access shall be provided in other areas. The Honeywell Serviceline series of controls is the University's preferred choice.
- B. Hot Water Control Valves: Hot water valves shall be either two-way or three-way. At least one three-way valve will be provided at the end of each hot water piping main to prevent dead-heading the pump and prevent the line from cooling. The Honeywell Serviceline series of controls is the University's preferred choice.
- C. Chilled Water Control Valves: Refer to 2.09 C for primary interface valve requirements.

All secondary chilled water valves shall be two-way valves and be able to shut off against thirty-five (35) psi differential pressure with no more than 0.5% maximum flow leakage. Three-way valves are not permitted. The Honeywell Serviceline series of controls is the University's preferred choice.

- D. Spring Ranges: Avoid using a single pneumatic output to control multiple actuators. If unavoidable, split spring ranges and opposing actuator operation (one normally open, one normally closed) shall be used. Reversing relays are not permitted.

2.04 CAMPUS EMCS INTERFACE HARDWARE AND CABINET

- A. General: The campus EMCS computer hardware and cabinet will be provided by the University. The Controls Contractor will install the computer cabinet. The University will install the computer hardware and arrange for the private network connection to the campus EMCS. The Controls Contractor will provide and install all field wiring to the cabinet. The University will make the final field wiring terminations in the computer cabinet. Reference Drawing MS-1 for cabinet size and space requirements.
- B. The Controls Contractor shall furnish and install a dedicated 120 VAC, 20 AMP electrical circuit and four-plex receptacle to the bottom of the EMCS computer cabinet. If emergency power is provided for the building, this circuit will be an emergency power circuit. Reference standard drawing MS-1 for circuit location.

2.05 FIELD TERMINAL PANELS

- A. Field terminal panels shall contain all relays, terminal blocks, I/P transducers, solenoid valves, etc., to connect the EMCS to field instrumentation, valve and damper actuators, motor control centers, etc. The only exception to this is that if the valve actuators or damper actuators are easily accessible, the associated I/P transducers or solenoid valves may be mounted on or near the actuators if a vibration free mounting surface is available. Coordinate Field terminal panel locations with the EMCS Shop Supervisor.
- B. Panels located indoor shall be NEMA 1, Panels located outdoors shall be NEMA 4. All panels shall have removable back plates, hinged front door, and hasp and staple for padlocking. All manual switches, pilot lights, digital displays, or analog displays (if required), shall be flush-mounted on the front face. Panels shall all use the same key.
- C. Each panel face shall have an engraved plastic tag bearing the panel number designated in the riser drawing. Each instrument or relay shall be tagged on the panel back plate with a machine printed tag bearing the EMCS item tag name, i.e. CISSF1ST, and EMCS computer wire number, i.e. 34-AI-07, for the instrument. Reference section 2.04D below for wire labeling requirements.
- D. Terminal strips shall be compatible with Entrelec series 5000, M,4/6 mounted on DIN-rail. Three alternating color termination blocks (blue-125.116.01, gray-115.116.07, green-105.001.27) shall be provided per wire pair. The blue termination block shall be used for the white positive (+) DC wire, the gray termination block shall be used for the black negative (-) DC wire, and the green termination block shall be used for the drain wire. Do not ground drain wires at remote field terminal panels (reference section 2.04.C.1.e). All multi-pair cable wire pairs including spares shall be landed in sequential order.

- E. All wiring and pneumatic tubing in field terminal panels to be in Panduit or equal wireway. Contact the Stanford Energy Services Group for a sample panel layout drawing.

2.06 CONDUIT, WIRING, AND WIRING LABELS

- A. Conduit: Conduit is required for all instrument wiring located outside, in mechanical rooms, or passing through non-accessible spaces. Wire runs within buildings may make use of communications cable trays and sleeves. Where trays are not available and wiring is not subject to mechanical abrasion, wiring may be run without conduits provided it is mechanically attached and supported every 48 inches. Wiring above removable ceiling tiles must be run at least 12 inches above the tiles. All conduit runs shall conform to the applicable National Electric Codes (reference division 16). For indoor applications, Electrical Metallic Tubing (EMT) can be used. Where conduit is required to instruments, install a minimum 24 inch length of flexible conduit at the instrument to allow removal of the instrument.
- B. Conduit Sizing:
 - 1. Conduit run between Field Terminal panels and field instrumentation shall be sized to provide an additional twenty-five percent (25%) of wiring capacity for future control modifications.
- C. Wiring:
 - 1. Instrument and Output Device Wiring Cables between Instruments and Cabinets or between Cabinets - 30 VDC and Less:
 - a. Multi-pair cable run between the EMCS enclosure and Field Terminal panels shall be sized to provide an additional 25% spare conductor pairs.
 - b. Single pair cable (Belden # 1033A or equal) shall be used between instruments and remote field terminal panels or EMCS interface cabinet. Multi-pair cable may be used between the EMCS cabinet and field terminal panels provided multi-pair cable is properly terminated (see 2.02 for terminal strip requirements). Either four (4) pair, eight (8) pair, sixteen (16) pair, twenty-four (24) pair, or thirty-six (36) pair wire may be used (Belden # 1056A, 1057A, 1059A, 1060A, 1061A or equal).
 - c. Instrument cables routed through air plenums shall be U.L./NEC listed, PL plenum rated, TEF jacketed, overall shielded 20 AWG stranded copper paired conductors with single 20 AWG stranded copper drain wire. If not in air plenum, cables may be U.L./NEC listed, PLTC rated, PVC jacketed, overall shielded 20 AWG stranded copper paired conductors with single 20 AWG stranded copper drain wire.
 - d. Cables shall be continuous and without splices except at field terminal panels. Cable jacket must extend into I/O device wiring cavity. In no case shall single or multi-pair cable be separated or spliced in j-boxes.

- e. Cable drain wires shall be grounded only at the EMCS cabinet. This termination is part of the University's scope of work. If splicing into a multi-pair cable at a field terminal panel, all I/O cable drain wires must be jumpered together and with the drain wire of the multi-pair cable to which they are spliced. Do not ground drain wires at remote field terminal panels. Drain wires at instruments shall be cut flush with cable jacket to prevent grounding at instrument.
 - f. Instrument and output device wiring shall be run only in conduit and cable trays of similar wire type and use. In no case may I/O wiring be run in same raceway with alternating current.
2. Instrument and output device wiring within cabinets - 30 VDC and less: Wire shall be 18 AWG THHN stranded copper. Use black wire insulation jacket for negative (-) wire and white for positive (+) wire.
 3. Interconnect Wiring - All AC wiring: Refer to Division 16

D. Wire Labels:

All instrument and output device wiring shall be labeled at every termination including both sides of interim splices within field terminal panels. Labels are required for wire pairs, and not for individual wires. Labels shall be installed within two (2) inches of termination, or in the case of I/O devices around the wire jacket anywhere in the device wiring cavity within six (6) inches of termination. Labels shall be machine printed with indelible ink on plastic tubing. In no case are self-adhesive labels accepted, unless machine printed and protected with clear heat shrinkable tubing. Label names shall reflect the EMCS computer number, I/O type and I/O number i.e. 340-AI-01-7, and the EMCS item detail tag name, i.e. SF1_ST. Tag names and numbers shall be on separate lines. The university shall provide the tag names and numbers after the final instrument list is generated.

2.07 INSTRUMENT AND CONTROL SPECIFICATIONS

- A. General: Refer to sections 2.06 through 2.12 for specific manufacturer requirements for specific applications.
- B. Electronic Temperature Transmitters and Sensing Elements: Transmitters shall be nominal 24 VDC loop powered (2-wire) 4-20 mA output designed for 3 or 4 wire 100 ohm platinum RTD temperature sensing elements. Accuracy shall be equal to or better than 0.1% of calibrated span. Sensing elements shall be 3 or 4 wire 100 ohm platinum RTD's with temperature coefficient of resistance = 0.003850 ohms/ohm/°C. Accuracy shall be equal to or better than $\pm 0.6^{\circ}\text{F}$ at 32°F.
- C. Electronic Pressure Transmitters-PSIG Ranges: Transmitters shall use capacitance sensing element and be nominal 24 VDC loop powered (2-wire) 4-20 mA output. Accuracy shall be equal to or better than 0.5% of calibrated span.

- D. Electronic Pressure Transmitters - IWC Ranges: Transmitters shall be nominal 24 VDC loop powered (2-wire) 4-20 mA output. Accuracy shall be equal to or better than 1% of calibrated span.
- E. Electronic Humidity Transmitters: Transmitters shall be thin film capacitance type and nominal 24 VDC loop powered (2-wire) 4-20 mA output. Accuracy shall be equal to or better than 2% of calibrated span between 20% and 80% relative humidity.
- F. Electronic pH Transmitters: Transmitters shall be nominal 24 VDC loop powered (2-wire) 4-20 mA output. Accuracy shall be equal to or better than 1% of calibrated span.
- G. Current/Pneumatic Transducers: I/P transducers shall be 4-20 mA input, 3-15 psig output, with output gauge port and 0-30 psig pressure gauge. Linearity shall be equal to or better than $\pm 1.0\%$ of span. Repeatability shall be equal to or better than 0.5% of span. Air consumption shall not exceed 0.1 SCFM at midrange.
- H. Control Relays: Control relays shall be used to isolate instrumentation wiring and power supplies from foreign voltage sources. Digital outputs from the EMCS shall operate octal base DPDT 24 VDC relays with pilot LED. The contact rating shall be ten (10) amps at 250 VAC, unless higher ratings are required for the particular job.
- I. Solenoid valves: Solenoid valves shall be 120 VAC.
- J. Digital Inputs: Each digital input shall be a contact closure (or opening) having no power on it other than that provided by the EMCS. If interposing control relays are required, they shall be octal base relays with pilot LED and 10 AMP contacts.
- K. Alarm Signals: All sensor and alarm contacts shall be closed in normal operation and shall open on alarm condition.

2.08 CHILLED WATER METERING

- A. Instrumentation: Chilled water supply flow, supply/mix/return temperatures, and supply/mix/return pressures shall be measured for each building receiving chilled water. The following instruments shall be used:
 1. Flow Tube: Rosemount Model No. 8711-T-S-A-Size-R-1
 2. Flow Transmitter: Rosemount Model No. 8712C-R-12.
 3. Temperature Transmitter: Rosemount Model No. 3144D1NAB4M5.
 4. Temperature Element: Rosemount Model No. 0068N21N00A (Insertion length) - T20 four wire RTD
 5. Thermowells: 304SS-(reference standard drawing MS-4)
 6. Pressure Transmitters: Refer to section 2.05 for transmitter requirements.
- B. Calibration and Sizing: Calibrated range for the temperature transmitters shall be 30 to 80 degrees F. Calibrated range for pressure transmitters shall be 0-100 psig. Flow Tube size and calibration shall be determined by Stanford's Utilities Division of Facilities Operations.

C. Power and Wiring Requirements: A dedicated 120 VAC power circuit is required to the magnetic flow transmitter. A lockable disconnect is required at the flow transmitter so that the transmitter can be safely serviced. The signal cable from the flow tube to the flow transmitter shall be jacketed, overall shielded, 20 AWG stranded copper two conductor cable with 20 AWG stranded copper drain wire (Belden 8760 or equal). The power cable from the flow tube to the flow transmitter shall be shielded, jacketed, overall 14 AWG stranded copper two conductor cable with 16 AWG stranded copper drain wire (Belden 8720 or equal).

D. Installation: Reference MS-10. The upstream and downstream runs of the flow meter shall be straight and without taps, feed-ins, and thermowells for the following number of pipe diameters:

Upstream - 10 pipe diameters, minimum.

Downstream - 5 pipe diameters, minimum.

2.09 STEAM METERING

A. General: Steam flow and steam pressure for each building shall be measured for each building receiving steam. The following instruments shall be used:

Flow Transmitter: Rosemount Model 8800A-F-Size-S-A1-N-1-D-1-M5.

Pressure Transmitter: Rosemount Model 3051CG-4-A-5-2-A-1-A-M5

Thermowell: 304SS - reference standard drawing MS-4

B. Calibration and Sizing: Calibrated range for pressure transmitters shall be 0-300 psig. The thermowell is for future use by the University. Flow meter size and calibration shall be determined by Stanford's Utilities Division of Facilities Operations.

C. Installation: The flow meter shall be installed before the pressure-reduction station. The upstream and downstream runs of the flow meter body shall be straight without taps, feed-ins, and thermowells for the number of diameters as follows :

Upstream - 20 pipe diameters, minimum.

Downstream - 5 pipe diameters, minimum.

Pressure transmitters shall be mounted on wall or pipe stand. Mounting orientation of pressure transmitters shall be as shown in MS-20.

2.10 ELECTRICAL METERING

A. General: The building electrical service meter(s) are provided and installed under division 16. Conduit and wiring for the 4-20 mA output signal to the EMCS is the responsibility of the controls contractor and shall conform to section 2.03 and 2.04 of this specification.

2.11 CHILLED WATER INTERFACE CONTROL

- A. General: The building distribution system shall be designed as a primary/secondary system with booster pump and crossover bridge (Reference Standard Drawing MS-10). In no instance shall the building booster pump be allowed to operate in series with the campus distribution system. The building booster pump shall be controlled by the campus EMCS and will be used in conjunction with the interface valve to ensure the building returns 58°F water to the chilled water distribution system. The following instruments shall be used:
 - 1. Pressure Transmitter: Refer to section 2.05 for transmitter requirements.
 - 2. Temperature Transmitter: Rosemount model no. 3144D1NAB4M5.
 - 3. Temperature Element: Rosemount Model No. 0068N21N00a (Insertion length) - T20 four wire RTD
 - 4. Thermowell: 304SS-reference standard drawing MS-4
- B. Calibration and Sizing: Calibrated range for the temperature transmitters shall be 30 to 80 degrees F. Calibrated range for pressure transmitters shall be 0-100 psig.
- C. Chilled Water Interface Control Valve: The chilled water interface control valve shall be normally closed (N.C.) and able to shut off against sixty (60) PSI differential pressure with no more than 0.1% of maximum flow leakage. This valve shall be a Fisher series V150 or Dezurik series VPB valve with a pneumatic diaphragm actuator and positioner.
- D. I/P Transducers: The current-to-pneumatic (I/P) transducer shall be either a Bellofram type 1000, Control Air type 500-AC, Moore Industries type IPF, or the Fisher or Dezurik transducer available as an installed option with the control valve.
- E. Downstream Chilled Water Valves: Refer to 2.01 C.

2.12 STEAM AND HOT WATER INTERFACE CONTROLS

- A. Hot Water Temperature Transmitter: Refer to section 2.05 for transmitter requirements.
The calibrated range shall be from 100°F to 220°F.
- B. Steam Temperature Control Valve: The control valve shall be an industrial-grade normally closed (N.C.) valve capable of a 0.1% shut-off rating and rated for steam service. The control valve shall be a Fisher E series, or Dezurik series VPB valve with a pneumatic diaphragm actuator and positioner.
- C. I/P Transducers: The current-to-pneumatic (I/P) transducer shall be either a Bellofram type 1000, Control Air type 500-AC, Moore Industries type IPF, or the Fisher or Dezurik transducer available as an installed option with the control valve.
- D. Pressure-Reducing Regulator: For buildings that use steam for heating without interim hot water systems, i.e. steam radiators, the steam PRV shall be equipped with a solenoid valve to allow the EMCS to shut off steam to the building.

2.13 ELECTRONIC HVAC INSTRUMENTATION

Proven manufacturers of HVAC instrumentation are listed below. Replacements for listed equipment are normally stocked on campus. Any proposed substitutions must conform to section 2.05 above. For questions or clarification contact Stanford's Energy Services Group.

A. Air Flow Measurement:

1. For most systems where the turn down ratio is less than five-to-one, airflow can be measured with a multipoint pitot traverse probe. The Air Monitor Volu-probe is the University's preferred choice.
2. For most systems where high turn down ratios or a high degree of accuracy is required, airflow should be measured with a multi-point, hot wire anemometer type of instrument. The Kurz Instrument EVA 4000 or the Ebtron TAMS are the University's preferred choice.
3. A calibration tag shall be provided with each flow station indicating its calibrated range and associated output.
4. The appropriate upstream and downstream straight runs of duct for the instrument installations shall be based on the manufacturer's requirements.

B. Static and Differential Pressure Measurement - 0" to 10" Ranges: Dwyer, Setra or Ashcroft transmitters are the University's preferred choices.

C. Temperature Measurement: Appropriate mounting shall be used for the service, i.e., thermowells shall be used for fluids in pipe, duct mounting for air ducts, and wall mounts for space sensing. Thermowell-mounted RTDs shall be spring loaded and bottomed fully in the well. (Reference standard drawing MS-3). Weed Instrument series 700 or Intec Instrument are the University's preferred choices.

Calibration ranges:

Room Temperature	50-90°F
Cooling Duct Discharge Temperature	50-90°F
Heating Duct Discharge Temperature	60-100°F
Outside Air Temperature & Mixed Air Temp	20-120°F
Chilled Water Temperature	30-80°F
Heating Hot Water Temperature	100-220°F

D. Humidity Measurement: Vaisala or Cosa are the University's preferred choices.

E. I/P Transducers: Preferred Current-to-pneumatic (I/P) transducer manufacturers include Bellofram type 1000, Control Air type 500-AC, or Moore Industries type IPF.

2.14 PROCESS COOLING WATER SYSTEMS
Specifications in development

2.15 CONTROL AIR COMPRESSORS

- A. Control air compressor shall be Quincy QR-25 series equipped with Perfection Automatic Drain Valve Model No. 530-17, Hankinson or approved equal refrigerated air dryer sized for 32°F air, pressure regulating valve, coalescing type oil removal filter with minimum twenty (20) micron filtering capacity and thermometers and pressure gauges to indicate tank pressure, temperature and pressure in and out of air dryer, pressure in and out of filter and regulator. The installation shall include valving such that the air dryer, filter, and regulator can be bypassed and removed. There shall be a check valve and manual shutoff valve between the compressor and air tank so that the compressor can be removed without losing the air charge in the tank. The tank shall be equipped with a 1/4 inch female air chuck quick disconnect (ARO Corp. # 23002-XXX or approved equal) and a properly sized relief valve. The compressor motor shall be an energy-efficient model of proper horsepower for the compressor. Motor shall be equipped with fused motor starter with overload heat protection and a 0-10,000 run-hour meter without reset. Compressor shall be sized to afford 2/3 off time. A pressure switch shall be installed on the regulated control air to provide a remote alarm via the EMCS in the event of air system failure. In buildings where reliability is essential, a dew point sensor to be supplied by Stanford shall also be installed.

2.16 PROCESS TUBING

- A. Material: Tubing shall be copper for chilled water or control air service and stainless steel for steam service.
 - 1. Stainless Steel Tubing: Stainless steel tubing shall be 1/2 inch, 0.035 inch wall, 304 stainless steel.
 - 2. Copper Tubing: Copper tubing shall be 1/2 inch, 3/8 inch, or 1/4 inch as appropriate for the given service.
- B. Tube Fittings: All tube fittings other than sweated fittings shall be Swagelok or Parker A-Lok compression fittings. Brass fittings shall be used with copper tubing. Stainless steel fittings shall be used with stainless steel tubing.

2.17 CONTROL AIR PIPING

- A. Copper: Type "L" hard drawn
- B. Steel: Galvanized schedule 40.
- C. Nonmetallic: Polyethylene flame retardant, high density type FR tubing. Multi-tube bundles shall have numbered tubes and enclosed in flame retardant polyethylene jacket.

PART 3 EXECUTION

3.01 WORK QUALITY AND EXPERIENCE

- A. General: All work shall be performed in a competent, skillful and well executed manner with people of journeyman level experience in the associated trades involved. Apprentices shall work only in conjunction with a journeyman.

3.02 ACCESSIBILITY

- A. General: All instruments shall be installed such that they are accessible for removal, repair, or recalibration in place. All instrument cabinet doors shall allow full one hundred twenty (120) degree opening without interference. Any installation deemed by the University to be inaccessible shall be corrected by the Contractor at no extra cost to the University.

3.03 PROCESS TUBING INSTALLATION

- A. General:
 - 1. All process connection tubing other than vertical runs shall be sloped at the rate of 1/2 inch per foot. Steam and water connections shall slope from the process towards the transmitter or switch connections with no air traps. Air and gas connections shall slope up from the process towards the transmitter or switch connections with no liquid traps.
 - 2. Steam transmitters and switches shall be at least two feet below the line they sense.

3.04 INSTALLATION OF CONTROL AIR PIPING

- A. Adequately size all tubing runs so that all subsystems have ample capacity to handle the controls connected. Provide sectioning valves in air distribution system that divides the building into several areas of control which may be conveniently isolated for future maintenance and/or repair.
- B. Instrument air piping installed in accessible areas shall be copper or polyethylene tubing when permitted by local codes. Instrument air piping installed exposed in mechanical equipment rooms and shafts, or in concealed inaccessible areas shall be copper tubing. Polyethylene tubing is not be permitted in smoke control systems, buried locations, outdoor air intakes, outdoor locations, ducts, plenums and mechanical equipment rooms, for service in excess of 30 psig, or in any location in which the temperature may exceed 125°F.
- C. Use number coded tubing throughout with coding rapidly identifiable at points of control and equipment. No piping shall be concealed under or within duct insulation or acoustic lining. Air piping shall be run horizontally level and vertically plumb and parallel to building lines. Tubing shall be fastened and adequately supported to prevent sagging. Only tool-made bends in copper tubing shall be acceptable.
- D. Install piping so it does not interfere with the maintenance of process equipment such as the removal of tube bundles, pump casings, coils, etc. Instrument piping and tubing shall be installed so that there is sufficient space around the instrument

for servicing and adjustment. Connections to instruments shall be made so that disconnect and removal of each individual instrument can be made without distortion of tubing.

- E. Whenever copper tubing crosses from a vibration isolated piece of equipment to a stationary structure, or crosses a flexible connection, a short piece of plastic tubing (maximum length 12 inches) will be installed in between to absorb vibration. The final connection to moving control equipment, such as damper actuators, shall be made via a short section of plastic tube.

3.05 INSTALLATION OF WIRING

- A. Provide wiring for control devices, monitoring devices, instrumentation, and interlocks as required for a complete system. Coordinate with Divisions 15 and 16 for devices requiring wiring under this section.
- B. Run all wiring in compliance with the requirements of the electrical specification (Division 16) and in accordance with authorities and codes having jurisdiction. Provide separate conduit for control wiring under this section.
- C. Control wiring, power or signal shall be run in metallic conduit, except signal from room temperature sensor to terminal unit where ceiling space is accessible.
- D. Provide all EMCS wiring, including power wiring to DDCs and EMCS equipment. All power wiring for control system shall be from an emergency power panel.

3.06 INSTALLATION OF CONTROL EQUIPMENT

- A. Device locations are the responsibility of the Control Contractor. Group instrumentation on secure and accessible surfaces in an organized manner. Locations are to be consistent for each type of system. Each control device, field or panel mounted, shall be identified by an engraved plastic nameplate permanently attached to its enclosure.
- B. Sensors mounted on air ducts having exterior insulation shall be provided with standoff spacers with insulating material firmly fitted around spacers. Reference Drawing MS-21.
- C. Averaging temperature elements shall be installed in serpentine fashion supported by steel grid. Minimum coverage 1 linear foot of sensor element per 4 square feet of coil face area. Reference Drawing MS-23.
- D. Duct mounted Humidity sensing elements must be mounted in the supply fan discharge and at least 10 feet downstream of the humidifier.
- E. Wall mounted sensors shall be 42 inches above finished floor except in service corridors where subject to damage, where height shall be 5 feet unless otherwise noted. Provide insulated base where mounting on exterior wall is required. Provide

metal guards where mounted in mechanical, electrical, storage, maintenance areas or in any area where subject to damage. Reference Drawing MS-22.

- F. Locate pressure transducers within 50 feet of sensing point. Connect to sensors with tubing of diameter recommended by sensor manufacturer and as required to prevent signal phase lag. Provide gauge tees at transducer for connection to pressure gauge.
- G. Provide 1 inch diameter air pressure gauges at all I/P transducers to indicate pressure to each controlled device. Gauges are not required for zone control valves and dampers.
- H. Panels shall not be located directly underneath valves or other areas where they may be subject to water or heat damage. In addition, panels shall be mounted with the bottom no lower than 3 feet and the top no higher than 7 feet above the floor, with a minimum of 3 feet clearance at the front.

3.07 TRAINING

- A. The Contractor shall furnish the services of competent instructors who will give instruction in the adjustment, operation and maintenance (including pertinent safety requirements) of the equipment and system specified. The training shall be oriented toward the system installed rather than being a general training course. Each instructor shall be thoroughly familiar with all aspects of the subject matter they are to teach. The Contractor shall provide all equipment and material required for classroom training.

The training shall include but not be limited to:

1. General Equipment Layout
2. Troubleshooting Procedures
3. Preventive Maintenance Procedures
4. Sensor Maintenance and Calibration
5. Topics requested by Owner

3.08 CALIBRATION AND COMMISSIONING

- A. The calibration and commissioning procedure shall consist of validating field I/O calibration, loop checks, actuator stroking, and integrated system operation validation. Document all commissioning information on commissioning data sheets which shall be submitted to the University for approval prior to testing. Notify the EMCS and HVAC Shops of the testing schedule so that operating personnel may observe calibration and commissioning.
- B. Field I/O Calibration and Commissioning: Prior to system program commissioning, bring on-line each control device by:
 - 1. Performing a single point measurement validation of all analog devices.
 - 2. Verifying instrument ranges.
 - 3. Verifying and documenting binary switch settings
 - 4. Verifying and documenting actuator spring ranges.
 - 5. Verifying and documenting fail-safe position on loss of control signal.

Submit calibration data sheets. Data sheets shall include the device designation, the date of calibration and the name of person who performed calibration.

- C. EMCS Loop checks: Perform test of every control device with Stanford Personnel.
- D. System Program Commissioning: After control devices have been calibrated and loop control verified, each EMCS program shall be put on-line and commissioned. The EMCS Shop shall confirm that the program logic follows the approved software flow chart and sequence of operation. Each control loop shall be adjusted to provide stable control within the specified accuracies.
- E. Instrument Air Piping Pressure Test:
 - 1. Test all high pressure (80 psig) piping at 100 psig sustained for 24 hours. Pressure loss shall not exceed 10 psig at the end of the 24 hour test period.
 - 2. Test all low pressure (25 psig) piping at 30 psig sustained for 24 hours. Pressure loss shall not exceed 3 psig at the end of the 24 hour test period.
 - 3. Notify the EMCS and HVAC Shops of the testing schedule so that operating personnel may observe testing.

3.09 ACCEPTANCE TESTING

- A. Submit a detailed acceptance test procedure designed to demonstrate compliance with contract requirements at least 4 weeks before the start of testing. This procedure to be approved prior to the start of the testing.
- B. During acceptance testing provide services of a fully qualified building automation technician who is knowledgeable of the project.

- C. Using the commissioning test data the Owner and/or his representative shall select, at random, functions to be demonstrated. These functions shall be demonstrated by the Contractor in accordance with the acceptance test procedure. At least 15% of the systems functions shall be demonstrated. At least 95% of the functions demonstrated must perform as specified and documented on commissioning data sheets or the system must be re-tested.
- D. Furnish instruments required for testing. Submit catalog data on all instruments for approval prior to performance of tests.

Instrument Accuracy

Temperature: 0.5°F or 1/2% of full scale, whichever is less
Pressure: 1.0% PSI or 1/2% of full scale, whichever is less
Humidity: 2% RH
Electrical: 1.0% of full scale

- E. After the above acceptance tests are complete and the system is demonstrated to be functioning as specified, a thirty-day endurance test period shall begin. If the system functions as specified throughout the endurance test period requiring only routine maintenance and adjustment, the system shall be accepted. If during the endurance test period the system fails to perform as specified and cannot be corrected within eight hours, the Owner may request that the endurance tests be repeated after problems have been corrected.

3.10 SYSTEM TESTING

- A. General: Upon completion of all system start-up and checkout procedures, and while the mechanical systems are monitoring and controlling in a "normal operating" condition, the Controls Contractor and University shall jointly demonstrate the performance of the complete system to maintain flows, temperatures, levels, relative humidity, and pressures. The test shall cover a continuous time period of at least three consecutive days. The test must meet the particular building's design requirements to be considered passed and acceptable. Any failures shall require the test to be restarted.

END OF SECTION