**Design team note: This section applies to UNL outstate projects only. This section does not apply to city or east campus projects.**

# GENERAL

## SECTION INCLUDES

### Control dampers.

### Control valves.

### Actuators: control valves and dampers.

### Electronic sensors.

### Humidity sensors.

### Status sensors.

### Airflow measuring stations.

### Leak detection sensors.

### Control wiring.

### Miscellaneous accessories.

## SYSTEM DESCRIPTION

### The temperature control system for this project shall utilize all electric relays, actuators, etc. for all controlled devices.

### Provide complete and operational system of instruments and control elements and accessories as necessary required to operate mechanical systems, fulfill the intent of the plans and specifications and provide operating sequence as specified.

## REFERENCE SECTION 23 05 00 FOR THE FOLLOWING:

### QUALITY ASSURANCE

### REFERENCES

### SUBMITTALS

#### Product Data: Provide description and engineering data for each control system component. Include sizing as requested. Provide data for each system component and software module.

#### Shop Drawings: Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences. Submit schedule of valves indicating size, flow, and pressure drop for each valve.

#### Label each control device with setting or adjustable range of control.

#### All required electrical wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

#### Submit leakage and flow characteristics, plus size schedule for control dampers.

### PROJECT RECORD DOCUMENTS / OPERATION AND MAINTENANCE MANUALS

#### Project Record Documents: Record actual locations of control components, including panels, thermostats, and sensors and include in Maintenance Manuals. Revise shop drawings to reflect actual installation and operating sequences prior to including in Maintenance Manuals.

#### Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances in Maintenance Manuals.

### DELIVERY, STORAGE, AND HANDLING

### WARRANTY

#### Submit manufacturer’s warranty and ensure forms have been filled out in Owners name and registered with manufacturer.

### COORDINATION

#### All products listed in this specification section shall be coordinated with other trades prior to installation to ensure that all manufacturer requirements for installation (i.e. inlet/outlet distances, mounting locations, etc) have been satisfied. No additional compensation shall be awarded for controls component relocation due to lack of coordination.

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

##### Coordinate equipment with Fire Detection and Alarm systems to achieve compatibility with equipment that interfaces with that system.

#### The manufacturer’s authorized representative shall review and approve placement for each component location indicated on the plans, prior to installation. A written report shall be submitted to the engineer if any locations do not meet the manufacturer’s placement requirements.

## MAINTENANCE SERVICE

### Provide service and maintenance of control system for one year from Date of Substantial Completion.

### Provide complete service of controls systems, including call backs. Make minimum of 2 complete normal inspections at start of heating and cooling seasons to inspect, calibrate, and adjust controls, and submit written reports. Coordinate with commissioning plan.

# PRODUCTS

## CORROSIVE ENVIRONMENTS

### Where controls components are installed in the fume exhaust air stream, they shall be provided with corrosion-resistant materials and the assembly shall be suitable for its intended service.

## CONTROL DAMPERS

### Ruskin CD-60 or equal, unless scheduled differently on the Drawings.

#### Damper shall meet the leakage requirements of the International Energy Conservation Code by leaking less than 3 cfm/sf at 1” of static pressure and shall be AMCA licensed as a class 1A damper.

#### Frame: 16 gage galvanized steel structural hat channel with tabbed corners for reinforcement for 11 gage structural equivalence.

#### Blades: 14 gage equivalent thickness galvanized steel, roll-formed airfoil type for low pressure drop and low noise generation. Blade edge seals shall be Ruskinprene type or equivalent suitable for -72 deg F to 275 deg F mechanically locked into the blade edge.

##### Provide dampers with parallel blades for 2- position control.

##### Provide opposed blades for modulating control.

#### Jamb seals: flexible metal, compression type to prevent leakage between blade end and damper frame. Blade end overlapping frame is unacceptable.

#### Bearings shall be corrosion resistant, permanently lubricated stainless steel sleeve type turning in a n extruded hole in the damper frame.

#### Axles: Axles shall be hexagonal positively locked into the damper blade.

#### Linkage shall be concealed out of airstream, within the damper frame to reduce pressure drop and noise.

### Provide multiple sections and operators as required by opening size and sequence of operations, as indicated on the contract drawings.

## CONTROL VALVES

### Hydronic Control Valves:

#### Up to 2 inches (50 mm): Globe pattern, bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with backseating capacity repackable under pressure.

#### Over 2 inches (50 mm): lug style butterfly valve, ASTM A 536 ductile-iron body, bronze trim, stainless steel stem, EPDM seat and seal, renewable seat and disc.

#### Hydronic Systems:

##### Rate for service pressure of 150 psig at 250 degrees F.

##### Replaceable plugs and seats of stainless steel.

##### Size for 3 psig maximum pressure drop at design flow rate.

##### Two way valves shall have equal percentage characteristics, three way valves linear characteristics.

### Pressure Independent Hydronic Control Valves (where scheduled on drawings):

#### Control valves shall be pressure independent. The flow through the valve shall not vary more than +/- 5% due to system pressure fluctuations across the valve in the selected operating range. The control valve shall accurately control the flow from 1 to 100% full rated flow.

#### The valve bodies shall be of cast iron, steel or bronze and rated for 150 PSI working pressure. All internal parts shall be stainless steel, steel, Teflon, brass, or bonze.

#### Valves shall be DeltaPValves manufactured by Flow Control Industries or approved equivalent.

### Steam Systems Control Valves

#### Up to 2 inches: Globe pattern, Class 125 bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with backseating capacity repackable under pressure.

#### Over 2 inches: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.

#### Internal Construction: Replaceable plugs and stainless steel seats.

##### Single-seated valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.

##### Double-seated valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.

#### Sizing: For pressure drop based on the following services:

##### Two Position: 20 percent of inlet pressure.

##### Modulating for Steam 15 psig or less: 80 percent of inlet steam pressure.

##### Modulating for Steam 16 psig to 50 psig: 50 percent of inlet steam pressure.

##### Modulating for Steam above 50 psig: As indicated on drawings.

#### Flow Characteristics: Modified linear characteristics.

#### Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of operating (inlet) pressure.

## ACTUATORS: CONTROL VALVES AND DAMPERS

### Exact size and type of actuators shall be determined from valve and damper manufacturer's torque requirements, close off ratings, etc.

#### All control valves and control valve operators must be able to close valves against pump shut off head, or a minimum 100 psig close-off rating.

### All damper operators must be able to close dampers against fan shut off pressure. Provide sufficient number of damper operators to achieve unrestricted movement throughout damper range. Provide one damper operator for maximum 36 sq. ft. of damper section.

### Provide actuators with "normally open" or "normally closed" spring return positions as required by operation sequence or as required for freeze, fire, temperature protection.

### Actuators shall be powered either by 24 or 120 VAC as required. All power actuator wiring by Temperature Controls Contractor. Actuator must have built-in overload protection to prevent damage to actuator when damper reaches its end position. End switches are not acceptable. Provide 3 ft. cable for connection to a junction box.

### A manual release shall be provided on the actuator body.

### The actuator must be designed for a minimum life of 60,000 full cycles at full torque.

### The actuator must have the capability of adding an auxiliary switch or feedback potentiometer if required.

### Manufacturer shall warranty all actuators for a minimum of two years from the installation date.

## ELECTRONIC SENSORS

### WALL MOUNTED CARBON DIOXIDE SENSOR

#### Carbon dioxide sensor shall be wall mounted with non-dispersion-infrared technology for sampling, integrated temperature sensor. Measurement range shall be 0-3,000 ppm range with an accuracy of +/- 50 ppm or +/- 5% whichever is greater. 14°F to 140°F temperature range. LED display at sensor for status information. The annual sensor drift shall 20 ppm so that re-calibration is not required for five years. 0-10 VDC output to EMCS. Carbon dioxide sensor shall be Honeywell model C7242A or equivalent.

### TEMPERATURE SENSORS: RTDs AND TRANSMITTERS

#### Room Thermostats: Temperature sensor shall have as minimum, integral linearized 20K ohm nickel thermistor, +/- 1°F accuracy from 45° to 95°F, setpoint adjustment with degrees F absolute (where applicable), occupied/unoccupied override and white case.

##### Setpoint adjustment shall only be provided in the following spaces:

###### Laboratory spaces.

###### Offices and conference rooms throughout the facility.

##### Where setpoint adjustment is provided, it shall be limited to a range of +/- 5 deg F of the heating and cooling setpoints.

##### The room sensors for all other spaces shall not include setpoint adjustment capabilities.

#### Immersion and Airstream Temperature Sensors:

##### Resistance nickel temperature detectors with resistance tolerance of plus or minus 0.1 percent at 70 degrees F, interchangeability less than plus or minus 0.2 percent, time constant of 13 seconds maximum for fluids and 200 seconds maximum for air.

##### Measuring current maximum 5 mA with maximum self‑heat of 0.031 degrees F/mW in fluids and 0.014 degrees F/mW in air.

##### Provide 3 lead wires and shield for input bridge circuit.

##### Use insertion elements in ducts not affected by temperature stratification or smaller than one square meter. Use averaging elements in larger ducts or as indicated or specified. Use sensor length of 8 feet or 16 feet as required.

##### Insertion elements for liquids shall be with brass socket with minimum insertion length of 2‑1/2 inches. Provide extra brass socket directly adjacent to sensor socket for system calibration.

##### Outside air sensors: Watertight inlet fitting, shielded from direct rays of sun.

#### Electric, Low-Limit Duct Thermostats:

##### Snap-acting, single pole, single-throw, manual reset switch that trips if temperature sensed across any 12 inches of bulb length is equal or below set point.

###### Unless otherwise noted on drawings, initial setpoint shall be 35 deg F.

###### Bulb Length: Minimum 20 feet.

###### Quantity: One thermostat for every 20 sq. ft. of coil surface.

###### Low-limit duct thermostats shall be Johnson Controls model A70HA-1 or approved equal.

### HUMIDITY SENSORS

#### Elements: Contamination resistant, capable of ±2% RH accuracy, have field adjustable calibration and provide a linear proportional signal.

#### Room Sensors: With locking cover, matching room temperature sensors used, span of 20 to 80 percent relative humidity.

#### Duct and Outside Air Sensors: With element guard and mounting plate, range of 0 ‑ 100 percent relative humidity.

### PRESSURE TRANSMITTERS / TRANDUCERS

#### Static Pressure Trasmitters: Nondirectional sensor with suitable range for expected input (not exceeding 150 percent of maximum expected input), and temperature compensated.

##### Accuracy: 2 percent of full scale with repeatability of 0.5 percent.

##### Output: 4 to 20 mA.

##### Building Static-Pressure Range: 0 to 0.25 inch w.g.

##### Duct Static-Pressure Range: 0 to 5-inch w.g.

###### Verify that range is appropriate for anticipated static pressures when installed in Air-Handling Equipment.

#### Water Pressure Transducers: Stainless steel diaphragm construction, suitable for service; minimum 150 psig operating pressure; linear output 4 to 20 mA.

#### Water Differential-Pressure Transducers: Stainless steel diaphragm construction, suitable for service; minimum 150 psig operating pressure and tested to 300 psig; linear output 0 to 10 VDC proportional to differential pressure, compatible with the BAS.

##### Water: Units shall be wet/wet differential pressure capable of a bi-directional pressure range of +/- 50 psid. Accuracy shall be +/- 0.25% full scale with a compensated temperature range of 30 to 150 deg F and a maximum working pressure of 250 psig. Install transmitter in a pre-manufactured bypass valve assembly with shut-off valves, vent valves and a bypass valve, all enclosed in a NEMA 1 enclosure.

##### Setra model 230 with Kele model BVA-5 bypass valve assembly, or equivalent.

#### Differential Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.

#### Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA

## STATUS SENSORS

### Status Inputs for Electric Motors: Current sensing relay with current transformers, adjustable and set to 175 percent of rated motor current, with LED indicator. Current sensors on motors equipped with VFDs must be capable of detecting status down to 6Hz. Units shall be powered by monitored line, UL listed and CE certified, and have a five year warranty. Provide multiple wraps of wiring on motors 1 hp or less in order to increase signal strength.

## AIRFLOW MEASURING STATIONS

### EBTRON, Inc. Model GTC116-PC or approved equivalent.

#### Fan inlet measurement devices shall not be used unless indicated on drawings or schedules.

#### Each airflow/temperature measurement device (ATMD) shall consist of one to four sensor probes and a single, remote transmitter. Each sensor probe shall consist of one to eight independent sensor nodes in a gold anodized, aluminum 6063 alloy tube with 304 stainless steel mounting brackets.

#### Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. Chip thermistors of any type or packaging are not acceptable.

#### The temperature output of the ATMD can be used in place of the specified temperature measuring device (TMD) when the location of the ATMD and TMD are effectively the same.

#### Sensor Density Requirements:

##### Sensor density (#/area) affects minimum installed distances required from disturbance types. Published sensor density data by the product manufacturer shall be submitted for approval.

##### Should there be no published document indicating these relationships for a particular product, the number of individual sensor nodes provided for each rectangular location shall be as follows:

|  |  |
| --- | --- |
| Duct or Plenum Area (sq. ft.) | Total # Nodes / Location |
| < = 1 | 1 or 2 |
| > 1 to < 4 | 4 |
| 4 to < 8 | 6 |
| 8 to < 12 | 8 |
| 12 to < 16 | 12 |
| > = 16 | 16 |

#####  The number of individual sensor nodes for each rectangular location shall be maximized for performance within the placement conditions provided. In no instance shall field selected locations provide less distance between disturbances than required for maximum performance. When minimum distances allowed by the highest density of sensor distribution are exceeded, a lower density configuration that provides the same performance is acceptable.

##### The number of individual sensor nodes provided for each round or oval duct location shall approximate the total required for rectangular locations or be detailed in published documentation by the manufacturer.

##### Submittal documents shall include schedules indicating the number of sensors per location, the duct area and the equivalent density (#/area) for approval.

#### Thermistors shall be potted in an engineering thermoplastic assembly using water-proof, marine epoxy and shall not be damaged by moisture or direct contact with water.

#### Signal processing circuitry on or in the sensor probe is not acceptable.

#### Each sensing node shall be individually wind tunnel calibrated at 16 points to NIST traceable airflow standards.

#### Each sensing node shall be individually calibrated in constant temperature oil baths at 3 point to NIST traceable temperature standards.

#### All internal wiring between thermistors and probe connecting cables shall be Kynar jacketed.

#### Manufacturer shall provide UL listed, FEP jacketed, plenum rated cables between sensor probes and the remote transmitter.

#### Measurement Performance:

##### Each sensing node shall have a temperature accuracy of +/- 0.14 deg F over the entire operating temperature range of -20 deg F to 160 deg F.

##### Each sensing node shall have an airflow accuracy of +/- 2% of reading.

##### The ATMD shall be capable of measuring airflow rates over the full range of 0 to 5,000 FPM between -20 deg F to 160 deg F.

#### Integral Transmitter and Communications:

##### The transmitter shall be powered by 24 VAC, be over-voltage and over-current protected, and have a watchdog circuit to provide continuous operation after power failures and/or brown-outs.

##### The power requirement for the ATMD shall not exceed 22 V-A.

##### The transmitter shall determine the airflow rate and temperature of each sensing node prior to averaging.

##### The transmitter shall have two isolated and fused analog output signals and one RS-485 network connection.

##### Each analog output shall be field configurable as linear 0-5 / 1-5 VDC, 0-10 / 2-10 VDC or 4 -20 mA signals.

##### One analog output signal shall provide the average airflow rate.

##### One analog output signal shall be field configurable to output the average temperature, the velocity weighted temperature or a binary airflow alarm.

##### The RS-485 network connection shall be field configurable as BACnet MS/TP or Modbus RTU.

##### The RS-485 connections shall be capable of transmitting the average airflow rate, average temperature, individual airflow rates of each sensor node, and individual temperature of each sensor node and system status.

##### All integrated circuits shall be industrial rated for operation down to – 40 deg F.

##### All electrical plugs, receptacles and circuit board interconnects shall be gold plated.

#### Listings and Certifications:

##### The ATMD shall be UL 973 listed.

##### The ATMD shall be BTL listed.

## LEAK DETECTION SENSORS

### Buna-N float, stainless steel housing, 2 sensor wire, Gems Sensors Series DLP-2 or equivalent.

# EXECUTION

## INSTALLATION

### Control Wiring:

#### Install electrical components and use electrical products complying with requirements of applicable Division-16 sections of these specifications. Mount equipment at convenient locations and heights. Do not mount any panels or other electronic equipment such that it is attached to vibrating equipment such as air handling units.

#### The term "control wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connecting electric control devices.

#### Install complete control wiring system for control systems. Coordinate with other trades such that control wiring, transformers, and all other required items are provided and installed for all required components.

#### All control wiring exposed or installed in mechanical rooms/penthouses shall be run in conduit. Provide flexible conduit at connections to actuators and other controlled devices.

#### Concealed control wiring routed above acoustical ceiling is not required to be in conduit if allowed by code, but wire must be plenum rated. Clip wire to structural ceiling. All wiring to be run at right angles to building.

#### Provide multi-conductor instrument harness (bundle) in place of single conductors where number of conductors can be run along common path. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.

#### Low voltage control wiring shall be run in separate conduit from line voltage power wiring.

#### Number-code or color-code conductors, excluding those used for local individual room controls, appropriately for future identification and servicing of control system.

### Sequence work to ensure installation of components is complementary to installation of similar components in other systems.

### Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

### Ensure installation of components is complementary to installation of similar components.

### Install in accordance with manufacturer’s instructions.

### All devices shall be mounted appropriately for the intended service and location.

### Check and verify location of thermostats, humidity sensors and other exposed control sensors with plans and room details before installation. Locate 60 inches above floor on sensors without setpoint adjustment; locate at 48 inches above floor on sensors with setpoint adjustment. Align with lighting switches.

### Mount outdoor sensors indoors, with sensing elements outdoors and sun shield.

### Duct mounted sensors shall be provided with mounting brackets to accommodate insulation. Mounting clips for capillary tubes for averaging sensors are required.

### Provide separable sockets for liquids and flanges for air bulb elements.

### Install damper motors on outside of duct in warm areas. Do not install motors in locations at outdoor temperatures.

### Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.

### Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.

### Do not install controls components in areas below items which may potentially leak.

### Install steam pressure sensors in locations shown on drawings.

### Install hydronic pressure sensors on each hydronic system in locations shown on drawings.

## CALIBRATION AND RECALIBRATION

### Calibrate instruments.

### Make three-point calibration test for both linearity and accuracy for each analog instrument.

### Calibrate equipment and procedures using manufacturer’s written recommendations and instructions manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

### Flow:

#### Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.

#### Manually operate flow switches to verify that they make or break contact.

### Pressure:

#### Calibrate pressure transmitters at 0. 50, and 100 percent of span.

#### Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

### Temperature:

#### Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.

#### Calibrate temperature switches to make or break contacts.

### Stroke and adjust control valves and dampers without positioners, following manufacturer’s recommended procedure, so that valve or damper is 100 percent open and closed.

### Stroke and adjust control valves and dampers with positioners, following manufacturer’s recommended procedure, so that valve or damper is 100 percent open and closed.

### Provide diagnostic and test instruments for calibration and adjustment of system.

### Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

### At substantial completion, the contractor shall calibrate all humidity sensors according to the factory recommendations and demonstrate calibration of the sensor to the owner’s representative. At the end of the one year warranty, the control contractor shall recalibrate all humidity sensors.

END OF SECTION 23 09 01