

SECTION 23 09 13 - INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART I - GENERAL

1.1 SECTION INCLUDES

- A. Electronic Sensors, Switches, Relays, and Indicating Devices
- B. Pneumatic Sensors, Switches, Relays, and Gauges
- C. Control Valves
- D. Automatic Dampers
- E. Flow Meters

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Control Valves
- B. Flow Switches
- C. Flow Meters
- D. Thermowells
- E. Pressure Gauge Taps
- F. Automatic Dampers

1.3 RELATED SECTIONS

- A. *Section 01 91 13 – General Commissioning Requirements*
- B. *Section 23 05 19 – Meters and Gauges for HVAC Piping.*
- C. *Section 23 08 00 – Commissioning of HVAC*
- D. *Section 23 09 13.33 - Control Valves*
- E. *Section 23 09 13.34 - Control Valve Actuators*
- F. *Section 23 09 13.43 – Control Dampers*
- G. *Section 23 09 23 - Building Automation System (BAS) for HVAC*
- H. *Section 23 09 43 Pneumatic Controls System for HVAC*
- I. *Section 28 30 00 – Fire and Smoke Detection System*

1.4 RELATED DRAWINGS *[Note to PSC: Include as appropriate and edit to be specific to the project.]*

- A. *Drawing 23 09 05-01, Controls Symbols*
- B. *Drawing 23 09 05-02, Type VAV AHU, Minimum OA, Steam Preheat*
- C. *Drawing 23 09 05-03, Type VAV AHU, Minimum OA, HW Preheat*
- D. *Drawing 23 09 05-04, Type CV AHU, Minimum OA, Steam Preheat*
- E. *Drawing 23 09 05-05, Type CV AHU, Minimum OA, HW Preheat*
- F. *Drawing 23 09 05-06, Type CV AHU, 100%OA, Steam Preheat*
- G. *Drawing 23 09 05-07, Type CV AHU, 100%OA, HW Preheat*
- H. *Drawing 23 09 05-08, Type CV AHU, 100%OA, HW Preheat, Heat Recovery Loop*
- I. *Drawing 23 09 05-09, Type CV AHU, 100%OA, HW Preheat, Heat Wheel*

- J. *Drawing 23 09 05-10, Pressure Independent VAV Box with HW Reheat and Perimeter Radiation*
- K. *Drawing 23 09 05-11, Steam to Hot Water Heat Exchanger HW System Controls*
- L. *Drawing 23 09 05-12, Chilled Water Bldg Entrance Valve Flow Control Valve*
- M. *Drawing 23 09 13-1, Pressure Differential Instrumentation Piping*
- N. *Drawing 23 09 13-2, Static Pressure Instrumentation Detail*
- O. *Drawing 23 09 13-3, Central Chilled Water System Metering Station Detail*
- P. *Drawing 23 09 23-1, 40 Deg Freezestat-Elect CHW Valve Override*
- Q. *Drawing 23 09 23-2, 40 Deg Freezestat Pneumatic CHW Valve Override*
- R. *Drawing 23 09 23-3, Typical BAS Network Architecture*
- S. *Drawing 23 09 23-4, DDC Panel Installation Detail*
- T. *Drawing 23 09 23-5, General Safety Circuit*
- U. *Drawing 23 09 23 -7 Across the line starter (FVNR) Damper /Fan Motor Application*
- V. *Drawing 23 09 23-8 isolation Damper with VFD*
- W. *Drawing 23 09 23 -9 Air Flow Monitoring Stations (AFMS) Placement Details*
- X. *Drawing 23 09 43-1, Temperature Control Air Compressor Installation*
- Y. *Drawing 26 29 23 -01 Configured VFD control wiring from VFD supplier*
- Z. *Drawing 26 29 23 -02 Factory VFD wiring to field wiring terminal strip*

#### 1.5 RELATED EXHIBITS

- A. *Exhibit 23 09 23-08a, VAV Box Sequence of Operation*
- B. *Exhibit 23 09 23-09 AHU Standard VAV AHU Sequence of Operation*
- C. *Exhibit 23 09 23-14 Energy Recovery Wheel Standard Sequence of Operation*
- D. *Exhibit 23 09 23-15 Energy Recovery Run Around Coil Standard Sequence of Operation*
- E. *Exhibit 23 09 23-16 Two Pump HTX Sequence of Operation*

#### 1.6 SYSTEM DESCRIPTION

- A. Provide control system components consisting of thermostats, temperature sensors, pressure sensors, relays, control valves, dampers and operators, indicating devices, and other apparatus and accessories required to operate mechanical systems and perform functions specified.
- B. Provide guidance for selection and sizing of control valves and dampers. Selections shall be based on actual system design parameters with no “rule of thumb” methods of selection. Building Automation Systems (BAS) Contractor is responsible for the selection of valves, dampers, and actuators.
- C. Provide materials and labor necessary to connect factory-supplied control components to existing control systems.
- D. Unless specified otherwise, provide fully proportional components.
- E. Provide power supplies and interconnecting wire and conduit.

#### 1.7 SUBMITTALS

- A. Related Sections: The following Sections contain requirements that relate to this Section:
  - 1. *Section 01 33 23 – Shop Drawings, Project Data, and Samples*

2. *Section 01 77 00 – Closeout Procedures*
3. *Section 01 78 23 – Operation and Maintenance Data*

B. In addition, comply with the following specific requirements:

1. Provide damper and actuator shop drawings showing unique tag numbers for each device, equipment or system served, device model numbers, duct sizes, damper sizes, flow rates, velocities, calculated pressure drops, leakage rates, torque requirements, actuator model number, actuator torque capacities, and pilot positioner locations.
2. Select dampers to meet their intended service with respect to maximum approach velocities and maximum pressure differential.
3. Submit valve schedule shop drawing which indicates unique tag numbers for each device, equipment or system served, device model numbers, sizes, shutoff head, actuator, required air pressure, torque requirements for rotary valves, flow coefficients (Cv) for 10 percent and 100 percent travel, design flow, pressure drop calculations, actuator model number, actuator torque capacities, and pilot positioner locations.
4. Provide complete operating data, system drawings, wiring diagrams, and written detailed descriptions of sequences. One copy of the as-built control diagram shall be placed inside each control panel. Provide pocket inside the door. Another copy of the as-built control diagram shall be placed in the O&M manual.
5. Operation and Maintenance manuals shall be organized by specification number and shall have a table of contents and tabs for each piece of equipment or system. In addition to requirements listed in *Section 01 78 23 - Operation and Maintenance Data*, Operation and Maintenance manuals shall also include:
  - a. Copies of all shop drawings in both paper and electronic format. Electronic drawings shall be provided on CD-ROM in the AutoCAD format listed in *Section 01 78 39 – Project Record Documents* of these Standards.
  - b. Manufacturer's operation and maintenance instructions. Include parts lists of all items or equipment with exploded view of components with part numbers. Designate the specific model when several options are shown. Include CD-ROM if available.
  - c. Product data sheets, engineering data and manufacturer's installation instructions on each control system component. Include sizing criteria and calculations.
  - d. Contact information on local parts suppliers and service companies.
  - e. Composite Electrical Diagrams.
  - f. Actual location of control components, including panels, thermostats, and sensors. Include revised shop drawings to reflect actual installation and operating sequences.
  - g. Factory and field calibration and commissioning records.

#### 1.8 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years' experience.
- B. Installer: Company specializing in applying the work of this section with minimum three years' experience. Installers must be factory certified by the control system manufacturer.
- C. BAS Contractors are limited to firms regularly employing a minimum of 5 full time service people within 100 miles of the job site.

#### 1.9 WARRANTY

- A. General: Provide one-year warranty on all materials and labor upon substantial completion.
- B. Flow Meters: Each flow meter assembly shall carry a performance warranty of at least two years from the date of installation and startup. This warranty shall cover parts and labor for repair or replacement of the meter assembly. Performance during the warranty period shall satisfy the requirements listed in Part 2 – Products of this specification for accuracy and repeatability.

## PART 2 - PRODUCTS

### 2.1 ELECTRONIC SENSORS, SWITCHES, RELAYS AND INDICATING DEVICES

#### A. Temperature Sensors

##### 1. General

- a. Sensors shall be 1000 ohm Platinum RTDs with the following minimum performance:
  - (1) Temperature Coefficient of Resistivity (TCR) of .00385 ohm/ohm/°C for platinum RTD's.
  - (2) Accuracy of  $\pm 0.1\%$  at 32 degrees F (Class B) for platinum RTDs.
  - (3) Operating range of 0 to 99% Relative Humidity non-condensing.
- b. Thermistors are acceptable in VAV box applications downstream of reheat coils and where it's the manufacturer's only native option.
- c. Thermocouples with transmitters or pneumatic sensors with transmitters are not acceptable.

##### 2. Immersion Sensors

- a. RTD must be installed within a 316 stainless steel thermowell using a non-hardening heat conducting paste.
- b. Thermowell shall be machined from a solid piece of 316 stainless steel bar stock. Thermowell shall be rated for a minimum static pressure of 500 psig at the maximum operating temperature and be capable of withstanding water velocities of up to 27 fps.
- c. The sensor shall be mounted so that it extends into the flow stream to a minimum of 1/3 of the diameter of the pipe. For pipes greater than 10 inch diameter, thermowell shall be installed in a position 45 degrees from the bottom of the pipe.

##### 3. Duct Mounted Sensors

- a. For averaging service, provide 1000 ohm RTD sensing element. Sensing element shall have a minimum of 1 foot of sensor length for each 2 square feet of duct or coil area. Sensor shall be arranged evenly across the duct or coil such that no point in the duct or coil is more than 1 foot away from the sensor.
- b. Install stainless steel flanges where elements penetrate ducts. Support elements with appropriate clips on coil faces, or 1/2" conduit in open ducts and plenums.
- c. See related drawing detail.

##### 4. Space Temperature Sensors and Thermostats

- a. Electronic thermostats shall be used in conjunction with DDC VAV controllers. Pneumatic thermostats shall be used in all other locations.
- b. Each thermostat in an office, classroom, lecture hall, laboratory, or other nonpublic area shall incorporate an accessible setpoint adjustment feature.
- c. Each thermostat in a corridor, lobby, atrium, stairwell, lounge, restroom or other public area shall incorporate a blank cover with no adjustment feature.

- d. Each thermostat must digitally display the current setpoint and temperature.
  - e. Each thermostat must have an active communications port to allow access to the controller from a laptop computer.
5. Outdoor Air Temperature shall be a 1000 Ohm Platinum RTD sensor, preferably located on the north side of the building and shaded with sun shield. Sensor shall be located at least six feet above grade away from window wells and exhaust openings.
6. Freeze Protection Stats
- a. Sensing elements shall have a minimum of 1 foot of sensor length for each 1 square foot of duct or coil area. The element shall be of the vapor tension type, such that any 18" section along the entire length of measuring element is capable of triggering the switch. Sensor shall be arranged evenly across the duct or coil such that no point in the duct or coil is more than 6" away from the sensor.
  - b. For protection of cooling coils, locate sensing element on the upstream face of the cooling coil.
  - c. For protection of preheat coils with horizontal tubes, locate sensing element on the downstream side of the preheat coil making sure that the bottom horizontal run of the sensing element is at the same elevation as the bottom row of the steam coil. If there are multiple steam coils that are stacked and trapped separately, make sure the sensing element protects the bottom row of all coils. Preheat coils with vertical tubes require special consideration.
  - d. Furnish each thermostat with one single pole, single throw normally opened switch and one single pole, single throw normally closed auxiliary switch.
  - e. Setpoint range shall be 15 degrees F to 55 degrees F with a permanent stop set at 35 degrees F.
    - (1) Differential shall be fixed at approximately 5 degrees F, and supplied with manual reset.
  - f. Setpoint range shall be 15 degrees F to 55 degrees F with a permanent stop set at 40 degrees F.
    - (1) Differential shall be fixed at approximately 5 degrees F, and supplied with automatic reset.
  - g. Low Temperature T'Stat, - 35 deg. F manual reset freeze stat [Siemens 134-1504 or ACI/FS-2 (20')]
  - h. Low Temperature T'Stat, - 40 deg. F Auto reset freeze stat [Johnson Controls A70GA-1 or ACI/FS-2A (up to 50')]
  - i. For a corrosive environment, substitute a Minco Chill-Out Combination Sensor. For an aquatic facility, use an aluminum element.
  - j. See related drawing detail.

B. Pressure Instruments

1. General

- a. Select device suitable for intended application; water, steam, or air, static or differential.
- b. Select for appropriate range, including negative if applicable. Must be able to withstand all pressures expected in installed location without need for recalibration.
- c. Pressure transmitter shall be a loop-powered device.
- d. Pressure transmitter shall have zero and span adjustments on the device.

2. Static Pressure Instruments

- a. Hydronic

- (1) 100 percent solid state device, temperature compensated, suitable for pressures of 200 percent rated range with averaging to stabilize output, accuracy of  $\pm 0.25$  percent, and a 4-20 mA output.
- (2) SETRA Model 256 or *[Note to PSC: Include 2 additional Owner-approved manufacturers.]*

b. Air

- (1) 100 percent solid state device, temperature compensated, suitable for pressures of 200 percent rated range with averaging to stabilize output, accuracy of  $\pm 1$  percent, and a 4-20 mA output.
- (2) For duct-mounted application, install a manufactured static sensing probe per manufacturer's recommendations.
- (3) SETRA Model MRG with display or *[Note to PSC: Include 2 additional Owner-approved manufacturers.]* for low pressure application.
- (4) SETRA Model MRG or *[Note to PSC: Include 2 additional Owner-approved manufacturers.]* for high pressure application.

c. Steam

- (1) Shall be installed with impulse piping "pigtail", which must be filled with water before startup to prevent damage. These transmitters shall be installed on the pipe rack, below the steam pipe, away from dissipated steam heat.
- (2) Rosemount 3051T, YOKAGAWA **EJA530E**, Foxboro IGP10 with the following options:
  - (i) Gauge pressure
  - (ii)  $\frac{1}{2}$ " – 14 NPT female process connection
  - (iii) Silicone fill fluid
  - (iv) Wetted parts material shall be 316L SST
  - (v) Aluminum housing
  - (vi) Local display
  - (vii) Digital HART communication protocol and 4-20mA output
  - (viii)  $\frac{1}{2}$ " NPT conduit connection

3. Differential Pressure Instruments

a. Hydronic

- (1) Yokogawa **EJA110E**, Foxboro IDP10, Rosemount 3051CD
  - (i)  $\frac{1}{2}$ " – 14 NPT female process connection
  - (ii) Silicone fill fluid
  - (iii) Wetted parts material shall be 316L SST
  - (iv) Aluminum housing
  - (v) Local display
  - (vi) Digital HART communication protocol and 4-20mA output
  - (vii)  $\frac{1}{2}$ " NPT conduit connection
  - (viii) Mounting bracket kit

b. Air

- (1) 100 percent solid state device, temperature compensated, suitable for pressures of 200 percent rated range with averaging to stabilize output, accuracy of  $\pm 1$  percent, and a 4-20 mA output.
- (2) SETRA Model MRG series with display or ACI Model: A/DLP-001-W-U-D-A-3 Range: 0-1 in WC, A/DLP-010-W-U-D-A-3 Range: 0-10 in WC
  - a. BAS Contractor shall provide transmitter for each filter bank.
- (3) The static sensor tip shall be a minimum of 3 inches from the inside wall of the duct.

c. Steam (as applied to DP type flow measuring devices)

- (1) Shall be installed remotely, with device lower than the tap from the supply line. Impulse piping must be filled with water before startup to prevent damage. Impulse piping must be long enough to protect the transducer from excessive temperatures.
- (2) 100 percent solid state device, temperature compensated, suitable for pressures of 200 percent rated range with averaging to stabilize output, accuracy of  $\pm 0.25$  percent, and a 4-20 mA output.
- (3) Device shall be provided with HART communication protocol.
- (4) Yokogawa **EJA110E**, Foxboro IDP10, Rosemount 3051CD
  - (i)  $\frac{1}{2}$ " – 14 NPT female process connection
  - (ii) Silicone fill fluid
  - (iii) Wetted parts material shall be 316L SST
  - (iv) Aluminum housing
  - (v) Local display
  - (vi) Digital HART communication protocol and 4-20mA output
  - (vii)  $\frac{1}{2}$ " NPT conduit connection
  - (viii) Mounting bracket kit

4. Building Pressurization Instrumentation

- a. Provide an Air Monitor Corporation S.O.A.P. (Shielded Outdoor Air Probe) device or *[Note to PSC: Include 2 additional Owner-approved manufacturers.]* Install per manufacturer's recommendation.
- b. Indoor reference points shall be located as indicated on the drawings. Typically, points shall be located in a large, open area away from building entrances.

C. Humidity Sensors:

- 1. Vaisala HMD60U or HMW60U Humidity Transmitter, or ACI (Automation Components INC.) – A/RH2-O for outdoor application *[Note to PSC: Include 2 additional Owner-approved manufacturers.]* shall be installed. Accuracy of  $\pm 2\%$  RH and a 4-20 mA output required.
- 2. Transmitter shall have zero and span adjustments on the device.

D. OCCUPANCY SENSORS

- 1. Occupancy sensors (auto on/off) and vacancy sensors (manual-on, auto-off) shall be used.
- 2. Sensors shall be dual-technology type unless specifically contradicted for the application
- 3. Sensors shall be provided with extra set of auxiliary contact for VAV, and other TAB box controls.

4. Areas with automatic lighting controls shall have isolated output relay to HVAC DDC controls, independent of any manual override.
  5. Contractor shall provide a plan view drawing with occupancy sensors location and their coverage area and associated DDC control devices.
  6. Manufacturers: Hubbell, Watt Stopper, Leviton, Sensor Switch. Or equivalent.
2. *[Note to PSC: PSC will use different DCV (Demand Control Ventilation) strategies to optimize ventilation in a multiple zone VAV system. With this in mind, occupancy sensors shall be used in less densely occupied spaces such as private offices, open plan offices, or classrooms, and spaces that have a population that varies only a little. CO2 sensors shall be installed only in those zones that are densely occupied and experience widely varying patterns of occupancy, for example auditoriums, conference rooms and lounges. ]*

E. Carbon Dioxide Sensors:

1. CO<sub>2</sub> sensors shall use single-beam dual-wavelength non-dispersive infrared sensor.
2. Sensor shall be accurate to within 2.5 percent of full scale reading. Range shall be 0 – 2000 ppm. Sensor must provide long-term stability of ±5 percent of full scale for a minimum of 5 years.
3. Output shall be a 4-20 mA signal.
4. Vaisala model GMD20 or GMW20 series, and ACI CO<sub>2</sub> sensors (Wall Mounted: A/ESENSE-R, Duct Mounted CO<sub>2</sub> sensor: A/ESENSE-D, Outdoor CO<sub>2</sub> sensor: A/AENSE Outdoor.- *[Note to PSC: Include 2 additional Owner-approved manufacturers.]*
5. Transmitter shall have zero and span adjustments on the device. *[Note to PSC: PSC will follow standard practice for HVAC ventilation to provide the code required minimum outside air, which typically specifies minimum ventilation for the maximum design occupancy at all times. CO<sub>2</sub> sensors shall be used to optimize the amount of ventilation air provided. With CO<sub>2</sub> sensors in the return air plenum, the supply of ventilation air will start until after the space has been occupied, especially if the control system includes an occupancy sensor.*

F. Carbon Monoxide / Nitrogen Dioxide Sensors:

1. Sensors shall be electrochemical sensors for the detection of carbon monoxide and nitrogen dioxide.
2. Sensors shall have an accuracy of +/- 2% and a minimum sensor life expectancy of 3 years and shall be field replaceable.
3. Transmitter shall provide two separate proportional 4-20 ma outputs for carbon monoxide and nitrogen dioxide. The carbon monoxide analog output shall be ranged 0-100 ppm and the nitrogen dioxide output shall be ranged 0-30 ppm.
4. The transmitter shall have visible LED indication of proper sensor operation and shall be equipped with a manual jumper selection to drive the 4-20 ma outputs to selected values for testing interfacing to DDC systems or other devices.
5. The unit shall be an MSA ZGARD DS model Nema 4X enclosure *[Note to PSC: Include 2 additional Owner-approved manufacturers.]*
6. Transmitter shall have zero and span adjustments on the device.

G. Airflow Measuring Stations

*[Note to PSC: Airflow measuring control-Volumetric Airflow tracking method will be used if required by project. Preferred control option is Building pressure control- Differential Pressure Sensing and pressure distribution by utilizing instruments and devices as listed in section B. of this document.)*



1. Duct mounted airflow measuring stations utilizing thermal dispersion technology. Each sensing point shall measure both airflow and temperature using a pair of instrument grade, hermetically sealed, glass encapsulated thermistors. Thermistors resistance/temperature characteristics shall be traceable to NIST calibration standards.
2. Each measurement location shall produce a single, linear isolated 4-20 ma analog output signal for airflow and/or temperature where indicated. The system shall have the ability to perform self-diagnostics and produce an alarm, which can identify the source of malfunction. In the event of a sensor failure, the system shall ignore failed sensor(s), average remaining sensors and shall continue to operate. The unit shall be equipped with a 16 character alpha-numeric LCD display.
3. Sensor shall have an accuracy of  $\pm 2.0\%$  of reading with  $\pm 0.25\%$  repeatability. Sensors shall operate over a temperature range of  $-20\text{ }^{\circ}\text{F}$  to  $160\text{ }^{\circ}\text{F}$  and a relative humidity range of 0% to 99% (non-condensing). Electronics shall operate over a temperature range of  $-20\text{ }^{\circ}\text{F}$  to  $120\text{ }^{\circ}\text{F}$
4. The number of independent sensing points shall be per manufacturer's recommendations for the specified application as shown on drawings. The probe body shall be constructed of extruded aluminum alloy. Provide airflow straightening devices as per manufacturer's recommendations if the required minimum diameters of straight duct upstream and downstream of the device cannot be achieved in the area where the device is to be installed as designated on drawings.
5. Note to PSC: *[The Engineer shall show Air Flow sensor location on Ventilation plan view drawings and shall provide mechanical installation detail in coordination with other divisions.]* The Sensor shall be located in straight ductwork section where linear air flow is obtained. The sensor will have good access including access door when needed. If the sensor is located in Outside Air stream then filter will be provided upstream from this instrument. Instrument location shall be inspected by the UIUC Commissioning agent, and by the manufacturer representative prior to installation to verify size and location. Prior to startup of air handling systems, A.F.M. instruments shall be tested and calibrated by the manufacturer representative and written report shall be submitted to the owner.
6. The unit shall be an Ebtron Model GTA116-PC Thermal Dispersion Airflow measurement or VOLU-flo/OAM Air Monitor Corporation for minimum outside air application. Install in min. outside air damper. *[Note to PSC: Include in project documents UIUC Standard detail - Air Flow Monitoring Placement Detail 23 09 23 -09].*

#### H. Flammable Gas Detection

1. Flammable gas sensors shall use an infrared dual wavelength beam. The unit shall be NFPA 72 compliant and meet FM Approval 6320 for combustible gas detector performance.
2. Sensor accuracy shall be  $\pm 1\%$  for the range of 0-50%LEL and  $\pm 2\%$  for the range of 51-100%LEL. Sensor life expectancy at a minimum of 5 years.
3. Unit shall provide an integral scrolling LED display to allow field calibration and diagnostic messages to be displayed.
4. A 4-20 ma output and 3 relays shall be provided. The relays shall provide warning, alarm and fault indication to the DDC control system. The 4-20 ma output shall provide an output for the range of 0-100%LEL. The unit shall provide integral or remote sensor mounting to the transmitter.
5. The unit shall be a Sierra Monitor Corporation Model 5100-2B-IT or *[Note to PSC: Include 2 additional Owner-approved manufacturers.]*

I. Level Instrumentation

1. *[Note to PSC: When level instrumentation is required, F&S Engineering shall be consulted to determine the device needed for the specific application.]*

J. Signal Converters and Isolators

1. Isolation Modules – PR Electronics 4116 with 4501 LCD display or *[Note to PSC: Include 2 additional Owner-approved manufacturers.]* Isolation Modules shall be used when a voltage or current signal is transmitted between 2 devices that do not share the same power supply. They can be used to convert from current to voltage or vice versa and rescale the signal to an appropriate range. Protect each signal converter individually with Class CC fuse, or equivalent. Fuse holder shall be Bussmann Model CHCC, or equivalent. Mount Modules to DIN rail.
2. Electronic to Pneumatic Transducers – Converts 4-20 mA or 2-10 Volt input signal to a 0-15 psig output. Output signal shall be linear to the input signal. Johnson Controls EP-8000 or *[Note to PSC: Include 2 additional Owner-approved manufacturers.]*
3. Pneumatic to Electric Switches: Shall have adjustable setpoint with scale and adjustable differential. Voltage and amperage ratings of the contacts shall not be exceeded.
4. Pneumatic to Electronic Transducers: Advanced Control Technologies PTP 3/15 or *[Note to PSC: Include 2 additional Owner-approved manufacturers.]*

K. Power Supplies and Noise Suppression Devices

1. 24 Volt DC Power Supply

- a. Size Power supply a minimum of 33 percent larger than the total connected load to allow for expansion. Fuse the supply circuit at no more than 150 percent of full load capacity of the power supply. Fuse shall be Class CC, or equivalent. Fuse holder shall be Bussmann Model CHCC or equivalent, DIN Rail mounted.
- b. The output of the Power supply shall provide short-circuit protection.

2. Power Conditioners

- a. All microprocessor based controllers shall be powered from a 120 VAC circuit protected by a noise suppression device. The device shall provide a line regulation of +/- 1% and have a noise attenuation of 40 dB. The audible noise valve shall be less than 65 dBA. Provide overload capacity of 165 percent of rated current. Output harmonic distortion shall be less than 3 percent of RMS content.
- b. Sola CVS Power Conditioner – Transformer shall be sized based on a load but no greater than 150% of the connected load 23 -22- 112 -2 (120 VA), 23-23-125-8 (250 VA) or 23-23-150-8 (500 VA) or *[Note to PSC: Include 2 additional Owner-approved manufacturers.]*
- c. The Line side of the conditioner shall be protected by a Class RK1 fuse, Bussmann model LPN or equivalent, sized per Power Conditioner manufacturers requirements. The Load side of the conditioner shall be protected by a Class CC fuse, or equivalent. Load side fuseholder shall be Bussmann Model CHCC or equivalent, DIN Rail mounted. Maximum load side fuse size shall be 7 amperes.

L. Relays and Switches

1. Mount all relays and power supplies on DIN Rails in a NEMA 1 enclosure beside the DDC panel or in the controlled device and clearly label their functions. A NEMA 12 enclosure is required for outdoor or wet applications.
2. Control Relays: All Digital inputs/outputs shall use Tyco Gold Contact Relays model KHAU-17A16N, Allen-Bradley 700-HC14A1-4, or *[Note to PSC: Include 1 additional*

*Owner-approved manufacturers.*] Relay shall use a plug-in socket mount, with finger-safe terminals, Allen-Bradley 700-HN103, or equivalent.

3. High or Low Air Pressure Safety Switch: Differential pressure switch with double-pole, double-throw snap switch and enclosure.
  - a. Rated for pressure specified in sequence of control for fan system. (-5.5 to 5.5 inch WC. for most AHUs)
  - b. Electrical rating shall be 15 amps at 120-480 volts.
  - c. Setpoint adjustment shall be screw type located inside enclosure.
  - d. Provide optional manual reset for overpressure protection with all tubing, brackets, and adapters.
  - e. Device shall be mounted in a locked control panel.
  - f. Acceptable Manufacturer: Siemens Powers Air Flow Switch 141-0575 or Cleveland AFS460 or *[Note to PSC: Include one additional Owner-approved manufacturer.]*
4. Coordinate voltage and ampacity of all contacts, relays, and terminal connections of equipment being monitored or controlled. Voltage and ampacity shall be compatible with equipment voltage and be rated for fully ampacity of wiring or overcurrent protection of circuit controlled.

M. Circuit Protection

Unless specified otherwise, all fuses shall be Class CC, or equivalent. Fuse holders shall be Bussmann Model CHCC or equivalent, DIN Rail Mounted. Maximum size shall not exceed maximum capacity of conductor, or 7 Amps, whichever is less.

## 2.2 PNEUMATIC SENSORS, SWITCHES, RELAYS, AND INDICATING DEVICES

A. Acceptable Manufacturers

1. Schneider Electric Building Systems / TAC
2. Siemens
3. ACI – Automation Components Inc.
4. Andover
5. Johnson Controls
6. Honeywell

B. Temperature Sensors

1. Immersion Sensors

- a. Sensing element shall be installed within a 316 stainless steel thermowell using a non-hardening heat conducting paste.
- b. Thermowell shall be rated for a minimum static pressure of 500 psig at the maximum operating temperature and be capable of withstanding water velocities of up to 27 fps.
- c. The sensor shall be mounted so that it extends into the flow stream to a minimum of 1/3 of the diameter of the pipe. For pipes greater than 10 inch diameter, thermowell shall be installed in a position 45 degrees from the bottom of the pipe.

2. Duct Mounted Sensors

- a. For mixed air temperature and coil discharge temperature sensing provide a liquid filled averaging sensing element. Sensing element shall have a minimum of 1 foot of sensor length for each 2 square feet of duct or coil area. Sensor shall be

arranged evenly across the duct or coil such that no point in the duct or coil is more than 1 foot away from the sensor.

- b. Install stainless steel flanges where elements penetrate ducts. Support elements with appropriate clips on coil faces, or 1/2" conduit in open ducts and plenums.
- c. Duct Averaging Sensors: **ACI A/IK-2W-A-24'-GD** Averaging 24' GD, A/IK-2W-A-16'-GD Averaging 16'; **Siemens QAM2012.750** Duct AV SNSR, PT 1K OHM 24'; **BAPI 1K Ohm Platinum -A-24'-BB4**
- d. Duct Point Sensor – T.A.B. Box Sensor Model: **ACI A/IK-2W-D-X"-GD**; Siemens **536-811 100K** Ohm Duct Temp Sensor; Siemens **QAM2012.045** Duct Pt SNSR, PT 1K OHM; BAPI Immersion Probe with Nylon Fitting Temp Sensor **1K Ohm Platinum -I-X"-BB4**

### 3. Space Thermostats

- a. Each thermostat in an office, classroom, lecture hall, laboratory, or other nonpublic area shall incorporate an accessible setpoint adjustment feature.
- b. Each thermostat in a corridor, lobby, atrium, stairwell, lounge, restroom or other public area shall incorporate a blank cover with no adjustment feature.

### 4. Outdoor Air Temperature

- a. Outdoor Air Temperature shall be a remote bulb liquid filled sensor, preferably located on the north side of the building and shaded with sun shield. Sensor shall be located at least six feet above grade away from window wells and exhaust openings.

## C. Pressure Transducers

1. Provide pressure transmitters that provide a direct acting 3 to 15 psig output signal that is linear to the input signal. Select the scale of the pressure transmitter such that the expected control setpoint is in the middle of the range of the transmitter.
2. Differential transmitters shall be selected using the lowest range allowable.
3. On hydronic and steam systems the transmitter shall be rated for liquid service.
4. When measuring steam pressure the transmitter shall be installed lower than the tap from the supply line. Impulse piping shall be long enough to protect the transducer from excessive temperatures and be installed with impulse piping "pigtail", which must be filled with water before startup to prevent damage.

## D. Gauges and Thermometers

### 1. General

- a. Provide 1.5" minimum diameter air pressure gauges for indication of supply and control pressure at all thermostats (except room thermostats), EP valves, PE switches, valves, damper motors, and other points in the system where indication of air pressure is needed for operating and troubleshooting.
- b. Provide 3.5" minimum diameter pressure gauges for indication of pressure at control sensors and monitoring points where indication of system pressure is needed for operating and troubleshooting.
- c. Gauges for control air pressure indication shall be suitable for the application.
- d. Gauges shall be selected to accurately measure all operating pressures and to withstand all expected pressures.
- e. 3.5" size gauges shall be provided with a calibration screw to allow field calibration of gauges with transmitters.

### 2. Differential Air Pressure Gauge (DPG) for Monitoring Filters

- a. Provide a DPG suitable for internal pressures to 15 psig, accuracy of  $\pm 3\%$  of full scale throughout the entire range at 70 degrees F, 4" minimum diameter dials, resistant to shock and vibration. Ranges shown on the drawings.
  - b. Provide an adjustable high limit alarm that will be connected to the DDC system to notify the Owner when the filters are dirty. Output shall be Form C dry contacts.
  - c. Acceptable Product: Dwyer Series 2000 or *[Note to PSC: Include 2 additional Owner-approved manufacturers.]*
3. Draft Gauges in Systems of More Than 5000 CFM
- a. Shall be installed across all pre-filter and intermediate filter systems, across after-filters, and across low efficiency filters.
4. Thermometers
- a. Thermometers shall be alcohol filled glass-bulb or dial type.
  - b. Select an appropriate range for each thermometer based on the process being measured. Thermometer shall be able to withstand all expected temperatures without loss of calibration.
  - c. Thermometers in hydronic systems shall be installed in immersion wells with a non-hardening heat conducting paste. Separate thermometers shall be installed within 2 feet of each temperature sensor.

## 2.3 ELECTROMAGNETIC FLOW METERS FOR HYDRONIC SYSTEMS

### A. General

- 1. Provide flow meters as scheduled or otherwise indicated in documents.
- 2. Flow meters shall be of the electromagnetic type.
- 3. Flow meters shall be manufactured in conformance with ISO standards.

### B. Flow Meter Sensor

- 1. Flow meter shall incorporate ANSI class 150 flanged connections, a full line-size 304 stainless steel flow tube, 316 stainless steel electrodes and inner liner compatible with temperature and chemical content of flow media.
- 2. Flow meter shall be rated for 150 PSIG system pressure and shall have adequate structural integrity for flow rate equal to 150% of scheduled maximum initial or future flow rate, whichever is greater.
- 3. Flow meter shall be provided with adequate means for grounding process fluid (e.g. grounding rings or grounding electrode).
- 4. Flow meter shall be rated for flow media temperature and 140 degrees F ambient air temperature.
- 5. Flow meter sensor shall incorporate firmware for storage of pertinent parameters unique to meter.

### C. Liner

- 1. Liner material shall be EPDM for media temperatures up to 140 degrees F.
- 2. Liner material shall be PTFE for media temperatures greater than 140 degrees F.

### D. Transmitter

- 1. Flow meter shall incorporate remote mounted programmable transmitter that incorporates a digital display.
- 2. Transmitter shall be rated for 140 degrees ambient air temperature.

3. Transmitter cable of 25 ft. minimum length shall be provided with each unit unless otherwise scheduled or noted within project documents. Cable length shall be adequate to satisfy specific installation requirements.
4. Electrical power input shall be 24VAC or 24VDC unless otherwise indicated within documents to be 120VAC.
5. Transmitter shall calculate and display flow rate and net totalized flow along with associated engineering units (i.e. GPM and Gal.) on a three line digital display. A password or external key shall be required to alter this display.
6. Transmitter shall provide two pulsed outputs, no exceptions. One pulsed output shall indicate incremental flow in one direction while the other indicates incremental flow in the opposite direction such that net totalized flow can be calculated remotely.
7. Transmitter shall produce a 4-20 mA output signal that is directly proportional to volumetric flow rate. A digital output shall indicate direction of flow.
8. Unless scheduled or otherwise indicated, the initial span adjustment of each transmitter shall be 0-120% of the scheduled maximum flow rate.
9. Transmitter shall incorporate self-diagnostics and test functions. It shall be capable of accomplishing following without use of external equipment:
  - a. Testing of all outputs and displays.
  - b. Verification of accuracy.
  - c. Verification of current loop integrity.
10. Upon power up, transmitter shall be capable of automatically uploading parameters resident within sensor firmware such that no operator configuration is required.
11. Transmitter shall incorporate a front facing optical port for communication of verified accuracy.
12. Transmitter shall be capable of downloading all test function results into a laptop computer.

E. Accuracy

1. Accuracy of each meter/transmitter assembly shall be  $\pm 0.25\%$  of flow rate reading over a range of 3-15 ft/sec fluid velocity, with a repeatability of 0.1%. Accuracy at 1 ft/sec shall be  $\pm 0.50\%$ .

F. Calibration

1. Each meter shall be calibrated on a NIST traceable flow stand at a minimum of three operating points. These three points shall be the flow rates associated with fluid velocities of 1.0 FPS, 8.0 FPS and 15.0 FPS. Written documentation of calibration shall be provided.
2. Each meter shall have factory fingerprinting to allow NIST traceable in-situ calibration verification to  $\pm 1\%$  of original factory calibration.

G. Warranty

1. Provide a one year manufacturer warranty.

H. Basis of Design

1. ABB Watermaster

PART 3 - EXECUTION

3.1 EXAMINATION

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

- B. Verify that all components are installed properly and calibrated to the proper operating range.

### 3.2 INSTALLATION - GENERAL

- A. Install all components as specified by manufacturer.
- B. All components shall be installed in a neat workmanlike manner.
- C. All wiring and pneumatic tubing shall be labeled on both ends as shown on as-built drawings.

### 3.3 FLOW METERS

- A. Remote Mounted Transmitter for Flow Meters shall be installed at BAS Control Panel or on wall or structure near flow tube in a clean dry location that is easily visible and with display easily readable.
- B. Each meter assembly shall include detailed installation and operation instructions that include piping straight run requirements. Meter installation needs to ensure the electrodes are always wet along with a maintenance bypass piping.
- C. Each bid shall include the cost of on-site start-up, commissioning and training.
- D. The BAS Contractor shall adjust DDC readout to match the measured airflow rates provided by the Balancing Contractor.

### 3.4 COMMISSIONING

- A. The instrumentation and controls devices shall be commissioned prior to start-up. See the related commissioning sections within these *U of I Facilities Standards* for commissioning requirements.
- B. Provide two seasonal system functional checkouts including seasonal changes (winter and summer modes).

### 3.5 METERS

- A. *[Note to PSC: Coordinate with Owner for Project-specific requirements.]*
- B. Reference *Drawing 23 09 13-3, Central Chilled Water System Metering Station Detail.*

END OF SECTION 23 09 13

This section of the *U of I Facilities Standards* establishes minimum requirements only.  
It should not be used as a complete specification.