

SECTION 230901 - BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS

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PART I. GENERAL

I.1 SECTION INCLUDES

- A. Pneumatic Tubing
- B. Wiring
- C. Control Valves and Actuators
- D. Control Dampers and Actuators
- E. Control Panels
- F. Sensors
- G. Pneumatic Control Components (Gauges, switches, relays, etc.)
- H. Electric Control Components (Switches, EP Valves, Thermostats, Relays, Smoke Detectors, etc.)
- I. Transducers
- J. Current Switches
- K. Nameplates
- L. Testing Equipment

I.2 RELATED DOCUMENTS

- A. Section ***{Insert Applicable Specification Section}***- Basic Mechanical Requirements
- B. Section 230900 - Building Automation System (BAS) General
- C. Section 230903 - BAS Field Panels
- D. Section 230904 - BAS Communications Devices
- E. Section 230905 - BAS Software and Programming
- F. Section ***{Insert Applicable Specification Section(s)}*** – Sequences of Operation
- G. Section 230801 - BAS Commissioning

I.3 DESCRIPTION OF WORK

- A. Refer to Section 230900 for general requirements.
- B. Refer to other Division-15 sections for installation of instrument wells, valve bodies, and dampers in mechanical systems; not work of this section.
- C. Provide the following electrical work as work of this section, complying with requirements of Division-16 sections:
 - 1. Control wiring between field-installed controls, indicating devices, and unit control panels.
 - 2. Interlock wiring between electrically interlocked devices, sensors, and between a hand or auto position of motor starters as indicated for all mechanical and controls.

3. Wiring associated with indicating and alarm panels (remote alarm panels) and connections to their associated field devices.
4. All other necessary wiring for fully complete and functional control system as specified.

I.4 WORK BY OTHERS

- A. Control Valves furnished under this section shall be installed under the applicable piping section under the direction of Section 230901 Contractor who will be fully responsible for the proper operation of the valve.
- B. Control Dampers furnished under this section shall be installed under the applicable air distribution or air handling equipment section under the direction of Section 230901 Contractor who will be fully responsible for the proper operation of the damper
- C. Water Pressure Taps, Thermal Wells, Flow Switches, Flow Meters, etc. that will have wet surfaces, shall be installed under the applicable piping Section under the direction of Section 230901 Contractor who will be fully responsible for the proper installation and application.
- D. All Controlled Equipment Power Wiring shall be furnished and installed under Division 16. Where control involves 120V control devices controlling 120V equipment, Division 16 Contractor shall extend power wiring to the equipment. Section 230901 Contractor shall extend it from the equipment to the control device. (i.e. Electrician installs power to motor, Controls Contractor wires relays, etc.)

PART II. PRODUCTS

II.1 MATERIALS AND EQUIPMENT

Edit the following to suit the project. The cost effectiveness of pneumatically driven actuators shall be assessed by the AE.

- A. General: Provide electronic, pneumatic, and electric control products in sizes and capacities indicated, consisting of valves, dampers, controllers, sensors, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.
- B. DEP Communications: Provide LonWorks to Modbus TCP universal gateway to allow transmitting of BAS data to DEP control panel.
- C. **Control Air Supply:** The Contractor may reuse existing control air in buildings where pneumatic controls will be replaced. The Contractor shall install air dryers and air filters so that all controllers and new pneumatic devices receive a clean and dry air supply. When the Contractor is reusing the existing air supply it shall be the responsibility of the Contractor to fully operate, maintain and assure the air supply is operated in the proper manner maintaining a clean, oil free, dry supply of control air to the new and existing controls.
 1. The control air filters shall remove oil and solid particles from the compressed air. Provide a dual prefilter and a final filter system. each of these requirements shall be provided for each filtering system. Each system shall be capable of being taken out

of service for repair and/or maintenance while the second system remains fully in operation. The prefilter shall be rated for 100 percent removal of all solids 1 micron and larger, 100 percent removal of liquid water, and 70 percent removal of oil aerosols with 2000 ppm maximum inlet liquid loading. The final filter shall be rated for 100 percent removal of liquid water and solids larger than 0.03 micron; 99.999 percent removal of oil aerosols with 100 ppm maximum inlet liquid loading. Filters shall include replaceable filter element, differential pressure gauge, and automatic liquid drain trap. Filters shall be selected for a maximum pressure drop of 2 psig at compressor capacity. Filter bodies shall be rated for 225 psig or greater operating pressure. Transparent acrylic tube housings shall be protected by a perforated steel safety shield. Filters shall be Hankison, DelTech, Wilkerson, or Arrow Pneumatics. Substitutions shall be allowed per Division 1. Furnish one (1) spare filter element per filter.

Edit the following to suit the project. AE shall consult with UNC personnel prior to specifying the dryers.

2. For systems where no pneumatic tubing is subject to temperatures below 40°F and without refrigerated dryers, provide an air-cooled refrigerated dryer with flow capacity at 100 °F, 100 psig saturated entering air and 40 °F leaving dewpoint equal to or exceeding air compressor capacity. Refrigerated dryer shall be a single package unit with all necessary piping, refrigerant, controls, wiring and accessories. Dryer shall include refrigeration system, on/off switch, inlet air pressure gauge, and water separator with automatic drain. Refrigerant shall be R-134a. System shall be labeled by CSA or UL. Manufacturer shall be Hankison, Wilkerson, DelTech, Ingersol-Rand or Arrow Pneumatics.
3. For systems with outdoor pneumatic components or components otherwise exposed to ambient conditions, provide a desiccant-type heatless self-regenerative air dryer for piping providing air supply to these components. Dryer capacity shall exceed connected load, plus a 30 percent allowance for expansion with inlet conditions of 100 deg f, saturated air at 100 psig, and outlet conditions of minus 40 °F dewpoint. Dryer maximum air pressure drop at rated flow shall not exceed 5 psig. Required air flow for regeneration shall not exceed 20 percent of dryer output capacity. Dryer shall include two desiccant towers, piping, changeover valves, exhaust silencers, controls and wiring. Desiccant towers shall be designed in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, and shall be ASME stamped for 125 psig working pressure, and fitted with suitable relief valves if tower physical size places tower within the scope of the Code where stamp is required. Desiccant dryers shall be as manufactured by Hankison, Deltech, Arrow Pneumatics, Ingersol-Rand or Zurn.
4. **Main Air Piping** (between the compressors and the field control panels): Hard drawn copper tubing, 1/4" OD and larger size as required, ASTM B 88, Type L.
5. **Branch Air Piping** (to include main air between field control panels and field devices: Seamless rigid copper tubing, 1/4" OD minimum size, Type K or L, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; except brass compression-type fittings at connections to equipment. Solder shall be 95/5 tin antimony, or other suitable lead free composition solder. *[Allow poly in conduit (EMT) for branch piping in lieu of copper. Install bushing at end of pipe.] Designer to verify with Owner.*

6. **Branch Air Piping Termination And Tubing Within Control Panels:** Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, 18" maximum length for terminations outside of panels. Use compression or push-on brass fittings.

D. Instrument Pipe and Tube

1. Hydronic and Instruments

- a) **Connection To Main Piping:** Provide ½ inch minimum size threadolet, ½" x 2 inch brass nipple, and ½" ball valve for connection to welded steel piping. Provide tee fitting for other types of piping.
- b) **Remote Instruments:** Adapt from ball valve to specified tubing and extend to remote instruments. Provide a union or otherwise removable fitting at ball valve so that connection to main can be cleaned with straight rod. Where manifolds with test ports are not provided for instrument, provide tees with ¼" FPT branch with plug for use as test port. Adapt from tubing size to instrument connection.
- c) **Line Mounted Instruments:** Extend rigid piping from ball valve to instrument. Do not use close or running thread nipples. Adapt from ball valve outlet to instrument connection size. Provide a plugged tee if pipe makes 90 degree bend at outlet of valve to allow cleaning of connection to main with straight rod without removing instrument. Where manifolds with test ports are not provided for instrument, provide tees with ¼" FPT branch with plug for use as test port.
- d) **Instrument Tubing:** Seamless copper tubing, Type K or L, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; or brass compression-type fittings. Solder shall be 95/5 tin antimony, or other suitable lead free composition solder. Tubing OD size shall be not less than the larger of ¼" or the instrument connection size.
- e) **Rigid Piping for Line Mounted Instruments:** Schedule 40 threaded brass, with threaded brass fittings.

2. Low Pressure Air Instrument Sensing Lines

- a) **Connections:** Use suitable bulkhead type fitting and static sensing tip for static pressure connections. Adapt tubing to instrument connection.
- b) **Tubing:** Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, installed in conduit. Use compression or push-on brass fittings.

- E. Communication Wiring:** All wiring shall be in accordance with National Electrical Codes and Division 16 of this specification. Communication wiring shall be provided in a customized color jacketing material. Material color shall be as submitted and approved by UNC. In addition all wiring jackets shall be labeled "BAS" in 3 foot or fewer intervals along the length of the jacket material.

1. Contractor shall supply all communication wiring between Controllers, Routers, BPOC(s) and LCS computer.
2. **Control LAN** For any portions of this network required under this section of the specification, contractor shall use Category 5 or better cable as specified in TIA-568B. Media shall be Class 2 plenum rated and installed in accordance with manufacturer's recommendations. Network shall be run with no splices and separate from any wiring over thirty (30) volts.

- F. **Signal Wiring:** Contractor shall run all signal wiring in accordance with National Electric Codes and Division 16 of this Specification.
1. Signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, etc. shall be twisted, 100% shielded pair, minimum 18-gauge wire with PVC cover. Signal wiring shall be run with no splices and separate from any wiring above thirty (30) volts.
 2. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.
- G. **Low Voltage Analog Output Wiring:** Contractor shall run all low voltage control wiring in accordance with National Electric Codes and Division 16 of this Specification.
1. Low voltage control wiring shall be minimum 18-gauge, twisted pair, 100% shielded, with PVC cover, Class 2 plenum-rated. Low voltage control wiring shall be run with no splices separate from any wiring above thirty (30) volts.
- H. **Control Panels:** Provide control panels with suitable brackets for wall mounting for each control system. Locate panel adjacent to systems served. Mount center of control panels 60" above finish floor or roof.
1. **Interior:** Fabricate panels of 16-gage furniture-grade steel, totally enclosed on four sides, with removable perforated backplane, hinged door and keyed lock keyed to the UNC Approved Control Panel Key, with manufacturer's standard shop- painted finish and color.
 2. **Exterior:** 16-gauge 304 Stainless Steel NEMA 4X enclosure. Panel shall have hinged door and keyed lock.
 3. Provide UL-listed cabinets for use with line voltage devices.
 4. Control panel shall be completely factory wired and piped, and all electrical connections made to a terminal strip.
 5. All gauges and control components shall be identified by means of nameplates.
 6. All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover.
 7. Provide a 6"x6" metal wiring/tubing trough across the entire width of the panel mounted to the top of the panel with close nipples of sufficient size for additional 50% wiring and tubing capacity. Wiring/tubing troughs shall not be less than 24" in length. Control panel wiring shall be installed and distributed in the trough to minimize routing of wiring and tubing within the control panel.
 8. Complete laminated wiring and tubing termination drawings shall be attached to the interior of each panel of sufficient size to be easily readable.

II.2 RECIPROCATING AIR COMPRESSORS, GENERAL

- A. **Air Compressor System:** Provide duplex type belt driven air compressor.
1. Sizing of compressor and storage tank shall limit compressor starts to ten maximum per hour and 33 1/3 percent running time when handling a load equal to the air required for the controls being installed in this contract plus controls installed under future work as indicated.
 2. Size of compressors and storage tank shall be as indicated above.
 3. Equip air compressor system with the following:

- a) Low resistance intake air filter; central station control air filter rated for 97% efficiency at rated air flow; and pressure reducing station to reduce high-pressure air to pressure required by pneumatic control instruments. Provide combination filter-pressure reducing station, or separate filter and separate pressure reducing station.
 - b) High-pressure relief valve.
 - c) Rubber-cork vibration isolation mounting pads.
 - d) High-pressure ASME storage tank, with drain test cock and automatic moisture removal trap, capacity as shown on drawings.
 - e) Belt guards.
 - f) Pressure switches and gauges.
- B. Provide a prewired control panel containing alternation and combination motor starters with three phase overload protection. Electrical alternation set to operate each compressor alternately with provision for second compressor to start demand. Cycle compressor through pressure switch. If one compressor fails other automatically maintains air pressure.

II.3 STANDARD SERVICE CONTROL VALVES

Control valve sizing and selection is the initial responsibility of the AE and NOT left to the controls subcontractor. AE shall provide a valve schedule that lists the requirements of the valves for Cv, close off, temperature etc. This should be a result of analyzing the valves performance across the range of control. AE shall consult with UNC personnel prior to specifying control valves.

- A. **General:** Provide factory fabricated control valves of type, body material and pressure class indicated. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature in piping system. Provide valve size in accordance with scheduled or specified maximum pressure drop across control valve. Control valves shall be equipped with heavy-duty actuators, and with proper close-off rating for each individual application. Minimum close-off rating shall be as scheduled and adequate for each application, and shall generally be considered at dead head rating of the pump.

The following valves are for use in a standard installation.

B. **Plug-Type Globe Pattern for Water Service:**

1. **Valve Sizing:** Where not specifically indicated on the control drawings, modulating valves shall be sized for maximum full flow pressure drop between 50% and 100% of the branch circuit it is controlling unless scheduled otherwise. Two-position valves shall be same size as connecting piping.

Edit/Delete the following to suit the systems applicable.

2. **Single Seated (Two-way) Valves:** Valves shall have equal-percentage characteristic for typical heat exchanger service and linear characteristic for building loop connections to campus systems unless otherwise scheduled on the drawings. Valves shall have cage-type trim, providing seating and guiding surfaces for plug on 'top-and-bottom' guided plugs.

3. **Double Seated (Three-way) Valves:** Valves shall have linear characteristic. Valves shall be balanced-plug type, with cage-type trim providing seating and guiding surfaces on 'top-and-bottom' guided plugs.
4. **Temperature Rating:** 25°F minimum, 250°F maximum
5. **Body:** Bronze, screwed, 250 psi maximum working pressure for 1/2" to 2"; Cast Iron, flanged, 125 psi maximum working pressure for 2-1/2" and larger.
6. **Valve Trim:** Bronze; Stem: Polished stainless steel.
7. **Packing:** Spring Loaded Teflon or Synthetic Elastomer U-cups, self-adjusting.
8. **Plug:** Brass, bronze or stainless steel, Seat: Brass
9. **Disc:** Replaceable Composition or Stainless Steel Filled PTFE.
10. **Ambient Operating Temperature Limits:** -10 to 150°F (-12.2 to 66 °C)
11. **Acceptable Manufacturers:** Subject to compliance with requirements approved manufacturers are as follows:
 - a) Johnson Controls
 - b) Schneider Electric-TAC
 - c) Warren
 - d) Delta
 - e) Substitutions: *[Insert Applicable Specification Section](#)*

C. **Plug-Type Globe Pattern for Steam Service:**

1. **Valve Sizing:** Where valve size is not specifically indicated on the drawings, size modulating valves for applications of 15 psig or less for 80% of inlet gage pressure unless scheduled otherwise. Modulating valves for applications of greater than 15 psig shall be sized for 42% of inlet absolute pressure unless scheduled otherwise. Two-position valves shall be same size as connecting piping.
2. **Characteristics:** Modified equal-percentage characteristics. Cage-type trim, providing seating and guiding surfaces for plug on "top and bottom" guided plugs.
 - a) Working Temperature: 250°F minimum for saturated steam applications of 15 psig or less; 366°F minimum for saturated steam applications of greater than 15 psig up to 150 psig.
3. **Body:** Bronze, screwed, 250 psig steam working pressure for 1/2" to 2"; Cast Iron, flanged, 100 psig steam working pressure for 2-1/2" and larger for applications of 50 psig or less.
4. **Valve Trim, Plug, Seat and Stem:** Polished stainless steel.
5. **Packing:** Spring Loaded Teflon.
6. **Disc:** Replaceable Composition or Stainless Steel Filled PTFE.
7. **Acceptable Manufacturers:** Subject to compliance with requirements approved manufacturers are as follows:
 - a) Johnson Controls
 - b) Schneider Electric-TAC
 - c) Warren
 - d) Delta

e) Substitutions: {Insert Applicable Specification Section}

D. Butterfly Type: To be used for two-position control only, No Exceptions.

1. **Body:** Extended neck epoxy coated cast or ductile iron with full lug pattern, ANSI Class 125 or 250 bolt pattern to match specified flanges.
2. **Seat:** EPDM, except in loop bypass applications where seat shall be metal to metal
3. **Disc:** Bronze or stainless steel, pinned or mechanically locked to shaft
4. **Bearings:** Bronze or stainless steel
5. **Shaft:** 416 stainless steel
6. **Cold Service Pressure:** 175 psi
7. **Close Off:** Bubble-tight shutoff to 150 psi
8. **Operation:** Valve and actuator operation shall be smooth both seating and unseating. Should more than 2 psi deadband be required to seat/unseat the valve, valve shall be replaced at no cost to the Owner.
9. **Acceptable Manufacturers:** Subject to compliance with requirements approved manufacturers are as follows:
 - a) Jamesbury WS815
 - b) Bray Series 31
 - c) Invensys
 - d) Dezurik BGS

e) Substitutions: {Insert Applicable Specification Section}

E. Ball Type

1. **Body:** Brass or bronze; one-, two-, or three-piece design; threaded ends.
2. **Seat:** Reinforced Teflon
3. **Ball:** Stainless steel.
4. **Port:** 'V' style.
5. **Stem:** Stainless steel, blow-out proof design, extended to match thickness of insulation.
6. **Cold Service Pressure:** 600 psi WOG
7. **Steam working Pressure:** 150 psi
8. **Acceptable Manufacturers:** Subject to compliance with requirements approved manufacturers are as follows:
 - a) Johnson Controls
 - b) Belimo
 - c) Conbraco
 - d) Worcester
 - e) Nibco
 - f) Jamesbury
 - g) PBM
 - h) Invensys

i) Delta

j) **Substitutions:** *{Insert Applicable Specification Section}*

F. Pressure Independent Type

1. Valves shall be pressure independent and shall be used for a water service 2-1/2" and larger unless noted otherwise. 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 valves shall accurately control the flow from 0 to 100% full rated flow. A flow tag, furnished with each valve shall list flows at all the valve positions in 10 degrees rotation increments. A maximum of 5 psi shall be required to operate the valve pressure independently.
 - a) **Rangeability:** The valves shall have a turndown capability of at least 100:1.
 - b) **Body:** Bronze, flanged, 125 psi maximum working pressure.
 - c) **Operating Temperature:** 250°F.
 - d) **Pressure/Temperature ports (Pete's Plugs):** Taps shall be installed at the factory in each valve to measure the pressure drop through the valves to determine the valve flow rate.
 - e) **Acceptable Manufacturers:** Subject to compliance with requirements approved manufacturers are as follows:
 - 1) Delta P Valve by Flow Control Industries, Inc.
 - 2) Belimo.
 - 3) KTM valve by Flow Design.
 - 4) Alternate No. M-04: furnish and install Delta P valve by Flow Control Industries, Inc.

G. Rotary Segmented Ball Type for Steam Pressure Regulating Service:

1. Characteristics: Modified equal-percentage characteristics with 300:1 rangeability.
2. Body: Steel, flanged, 150 psig steam working pressure.
3. Ball: Stainless steel segmented ball
4. Valve Trim and Stem: Stainless steel.
5. Packing: Spring Loaded Teflon.
6. Seat: Reinforced Teflon
7. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
 - a) Fisher V150
 - b) Valtek ShearStream
 - c) Neles R-Series

II.4 CRITICAL SERVICE CONTROL VALVES

Control valve sizing and selection is the initial responsibility of the AE and NOT left to the controls subcontractor. AE shall provide a valve schedule that lists the requirements of the

valves for Cv, close off, temperature etc. This should be a result of analyzing the valves performance across the range of control. AE shall consult with UNC personnel prior to specifying control valves. Refer to the 'Control Valve Specification Sheet' located at the end of the document. AE shall complete the required fields designated on the Valve Sheet as noted and required.

- A. **General:** Provide factory fabricated control valves of type, body material and pressure class indicated on the 'Control Valve Specification Sheet' located at the end of this document. Contractor shall utilize the sheet to submit the control valves for the project. Valves shall be as manufactured by Fisher Controls International, Valtek Control Products, DeZurik/Copes-Vulcan, Leslie Controls Inc., or equal. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature in piping system. Provide valve size in accordance with scheduled or specified maximum pressure drop across control valve. Control valves shall be equipped with heavy-duty actuators and pilot positioners with proper close-off rating and capability for each individual application. Minimum close-off rating shall be as scheduled and adequate for each application, and shall generally be considered at dead head rating of the pump.

II.5 AIR VALVES

- A. The requirements of this Section shall apply to supply air valves, general exhaust air valves, snorkel exhaust air valves, and fumehood exhaust air valves.
- B. Air valves shall be designed for use in laboratory airflow control systems, and shall be provided with factory-mounted electric actuators. Air valves shall be rated for full capacity at 0.6" wg static pressure and leakage in the closed position shall not exceed 1% of the maximum valve rating at 3" wg operating static pressure, when mounted in any position. Air valves shall be pressure independent over the range of 0.6" wg to 3.0" wg.
- C. Air valves for supply and general exhaust service shall be minimum 22 gauge galvanized steel or aluminum. Air valves for fumehood, biosafety cabinet, and snorkel exhaust service shall be type 316 stainless steel or 16 gauge aluminum coated with 2 coats of a phenolic coating. Coatings shall be applied after valve assembly. Casing penetrations shall be coated.
- D. Discharge sound power levels, in dB re 10^{-12} watts, at 2.0" wg shall not exceed:

Size	Airflow	Octave Band Frequency (Hz)				
		125	250	500	1000	2000
6"	300 cfm	62	65	68	67	62
10"	900 cfm	71	70	73	71	65
12"	1500 cfm	76	74	75	71	68
14"	2400 cfm	83	76	72	73	67

- E. Individual valves shall not exceed 14" diameter and 2500 cfm, and shall have ANSI standard inlet and outlet flanges. Where larger capacities are required, provide factory assemblies utilizing multiple valves complete with flanged inlet and outlet connections. Multiple valve assemblies shall be sequenced so that only one valve is modulating at a time. Provide individual actuators and

positive positioners for each valve in the assembly. Actuators shall be factory-mounted.

- F. Valves shall have a minimum 10:1 turndown ratio. Supply valves shall be normally closed and exhaust valves normally open.
- G. Manufacturer: Phoenix Controls Accel II, Tek-Air Systems Accuvalve, or TSI Venturi.

II.6 FUMEHOOD CONTROL SYSTEMS

- A. Fumehood control systems shall consist of an airflow, velocity, pressure, or sash position sensor; controller; hood-mounted user alarm interface; air valve and actuator; and interconnecting wiring. Controllers shall comply with UL 916-2007 and shall be stand-alone, closed loop devices dedicated to the individual laboratory fumehood. Controllers shall maintain face velocity setpoint regardless of duct static pressure and sash position changes. Controllers shall have a minimum input sampling rate of 10 times per second; shall update outputs no less than once a second; shall have a control accuracy of $\pm 5\%$ of setpoint; shall respond to a change in face velocity within 1 second; and shall attain setpoint face velocity within 3 seconds.
- B. Controllers:
 - 1. Controllers shall be individual industrial process control quality, solid state microprocessor-based, field programmable devices capable of performing the sequence of operation specified herein.
 - 2. Controllers shall communicate with the BAS through a data communications interface. Information transferred shall include fumehood exhaust volume, sash position, volume/velocity reset, and master alarm status.
- C. User Alarm Interface:
 - 1. User alarm interface shall be mounted on the laboratory fumehood with digital indication of average face velocity. The interface shall have green and red status light for safe or alarm condition with adjustable alarm limits.
 - 2. The user alarm interface shall alarm low face velocity, high face velocity and general failure. An audible alarm shall be provided with a mute button.
- D. Air Valves: as specified in Paragraph 2.5, Air Valves.
- E. Sensors:

1. Airflow sensors: single or multiple point velocity measuring sensors, arranged to measure and average the flow velocity across the area of the duct. Averaging airflow probes shall be designed to sample flow in 10 equal duct area increments across the entire exhaust duct width. Probes shall be type 304 stainless steel. Each airflow insertion probe shall be provided with a gasketed duct mounting plate and threaded end support. Sensors shall be resistant to the effects of changing temperature, humidity, static pressure, dust, and dirt in the air stream.
2. Velocity sensors: bidirectional, industrial grade, temperature compensated or thermal anemometer type. Sensors shall be capable of measuring velocities in a range of 0 fpm to 2000 fpm with a display resolution of $\pm 5\%$ of reading. Velocity sensors shall be through-the-wall, or ceiling-mounted and referenced to the space indicated on the Drawings.
3. Pressure sensors: surface-mounted in housings complete with multiple sensing ports, pressure impulse suppression chamber, and airflow shielding. Sensors shall be capable of measuring static pressure to within 1% of the actual value when subjected to a radial airflow of up to 1000 fpm. Housings shall be finished on exposed surfaces and shall be stainless steel. Space differential pressure transmitters shall have a range of -0.2" wg to +0.2" wg. Sensors shall be capable of measuring pressure to 0.00015" wg. Sensors shall be bidirectional to determine the proper direction of pressure. End-to-end transmission accuracy shall be 1.0% including linearity, hysteresis, and repeatability. Each sensor shall include an NIST traceable calibration certificate.
4. Hot wire anemometers: bidirectional industrial grade temperature compensated mass flow type, capable of measuring velocities over a minimum range of 0 fpm to 150 fpm for fumehoods and 0 fpm to 1000 fpm for air volume measurements, with a resolution of $\pm 5\%$ of range. Sensors shall automatically detect a change in direction of flow and report a positive or negative flow, as appropriate.
5. Sash position sensors: precision, linear devices with repeatable location accuracy within 1", corrosion-resistant, able to withstand salt fog (marine) tests, with an operational life span of at least 250,000 cycles. Sensor installation shall allow for complete and easy removal of sashes for cleaning or maintenance.

F. Wiring: as specified in Paragraph 2.1, Materials and Equipment.

G. Manufacturer: Phoenix Controls, Tek-Air Systems, or TSI.

II.7 CONTROL DAMPERS

- A. **General:** Provide factory fabricated automatic control dampers of sizes, velocity and pressure classes as required for smooth, stable, and controllable airflow. Provide parallel or opposed blade dampers as recommended by manufacturers sizing techniques. For dampers located near fan outlets, provide dampers rated for fan outlet velocity and close-off pressure, and recommended by damper manufacturer for fan discharge damper service. Control dampers used for smoke dampers shall comply with UL 555S. Control Dampers used for fire dampers shall comply with UL 555.

- B. For general isolation and modulating control service in rectangular ducts at velocities not greater than 1500 fpm (7.62 m/s), differential pressure not greater than 2.5" w.c. (622 Pa):
1. **Performance:** Test in accordance with AMCA 500.
 2. **Frames:** Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.
 3. **Blades:** Stainless steel in lab exhausts and galvanized steel elsewhere, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts with set screws, 16 gauge minimum thickness.
 4. **Blade Seals:** Synthetic elastomer, mechanically attached, field replaceable.
 5. **Jamb Seals:** Stainless steel.
 6. **Shaft Bearings:** Oil impregnated sintered bronze, graphite impregnated nylon sleeve or other molded synthetic sleeve, with thrust washers at bearings.
 7. **Linkage:** Concealed in frame.
 8. **Linkage Bearings:** Oil impregnated sintered bronze or graphite impregnated nylon.
 9. **Leakage:** Less than one percent based on approach velocity of 1500 ft./min. (7.62 m/s) and 1 inches wg. (249Pa).
 10. **Maximum Pressure Differential:** 2.5 inches wg. (622 Pa)
 11. **Temperature Limits:** -40 to 200 °F (-40 to 93 °C).
 12. Where opening size is larger than 48 inches (1219 mm) wide, or 72 inches (1829 mm) high, provide dampers in multiple sections, with intermediate frames and jackshafts appropriate for installation.
- C. For general isolation and modulating control service in rectangular ducts at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6" w.c. (1493 Pa):
1. **Performance:** Test in accordance with AMCA 500.
 2. **Frames:** Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.
 3. **Blades:** extruded aluminum hollow airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts, 14 gauge minimum extrusion thickness.
 4. **Blade Seals:** Synthetic elastomeric, mechanically attached, field replaceable.
 5. **Jamb Seals:** Stainless steel.
 6. **Shaft Bearings:** Oil impregnated sintered bronze sleeve, graphite impregnated nylon sleeve, molded synthetic sleeve, or stainless steel sleeve, with thrust washers at bearings.
 7. **Linkage:** Concealed in frame.
 8. **Linkage Bearings:** Oil impregnated sintered bronze or graphite impregnated nylon.
 9. **Leakage:** Less than 0.1 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa).
 10. **Maximum Pressure Differential:** 6 inches wg. (622 Pa)
 11. **Temperature Limits:** -40 to 200 °F (-40 to 93 °C).

12. Where opening size is larger than 48 inches (1219 mm) wide, or 72 inches (1829 mm) high, provide dampers in multiple sections, with appropriately intermediate frames, and jackshafts.
- D. For general isolation and modulating control service in rectangular ducts at velocities not greater than 4000 fpm, differential pressure not greater than 12" w.c.:
1. **Performance:** Test in accordance with AMCA 500.
 2. **Frames:** Galvanized steel, 12-gauge minimum thickness, welded or riveted with corner reinforcement.
 3. **Blades:** Extruded aluminum hollow airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 3/4 inch (19 mm) shafts with set screws
 4. **Shaft Bearings:** Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
 5. **Linkage:** 10-gauge minimum thickness galvanized steel clevis type crank arms, 3/16" x 3/4" (4.76 mm x 19 mm) minimum thickness tie rods.
 6. **Linkage Bearings:** Oil impregnated sintered bronze or graphite impregnated nylon.
 7. **Leakage:** Less than 0.2 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
 8. **Maximum Pressure Differential:** 12 inches wg. (2984 Pa)
 9. **Temperature Limits:** -40 to 300 °F (-40 to 149 °C).
 10. Where opening size is larger than 48 inches (1219 mm) wide, or 72 inches (1829 mm) high, provide dampers in multiple sections, with appropriately intermediate frames, and jackshafts.
- E. For general isolation and modulating control service in round ducts up to 40 inches in size at velocities not greater than 2500 fpm (12.7 m/s), differential pressure not greater than 4" w.c. (994 Pa):
1. **Performance:** Test in accordance with AMCA 500.
 2. **Frames:** rolled 12 gauge steel strip for sizes 6 inch and smaller, rolled 14 gauge steel channel for larger sizes, galvanized or aluminum finish.
 3. **Blades:** Steel construction, 12 gauge minimum thickness for dampers less than 18 inches (457 mm) in size, 10 gauge minimum thickness for larger dampers.
 4. **Blade Seals:** Full circumference neoprene.
 5. **Shaft:** 1/2 inch (12.7 mm) diameter zinc or cadmium plated steel.
 6. **Shaft Bearings:** Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
 7. **Leakage:** Less than 0.2 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
 8. **Maximum Pressure Differential:** 4 inches wg. (994 Pa)
 9. **Temperature Limits:** -40 to 300 °F (-40 to 149 °C).
- F. For general isolation and modulating control service in round ducts up to 60 inches in size at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6" w.c. (1492 Pa):
1. **Performance:** Test in accordance with AMCA 500.

2. **Frames:** rolled 10-gauge steel channel for sizes 48 inch and smaller, rolled 3/16 inch (4.76 mm) thick steel channel for larger sizes, galvanized or aluminum finish.
3. **Blades:** Steel construction, 10-gauge minimum thickness for dampers not greater than 48 inches in size, 1/4 inch (6.35 mm) minimum thickness for larger dampers.
4. **Blade stops:** 1/2 inch x 1/4 inch (12.7 mm x 6.35 mm) full circumference steel bar.
5. **Blade Seals:** Full circumference neoprene.
6. **Shaft:** zinc or cadmium plated steel, angle reinforcing as necessary.
7. **Shaft Bearings:** Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
8. **Leakage:** Less than 0.4 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
9. **Maximum Pressure Differential:** 6 inches wg. (1492 Pa)
10. **Temperature Limits:** -40 to 250 °F (-40 to 121 °C).

II.8 ACTUATORS

- A. **General:** Size actuators and linkages to operate their appropriate dampers or valves with sufficient reserve torque or force to provide smooth modulating action or 2-position action as specified. Select spring-return actuators with manual override to provide positive shut-off of devices as they are applied.

B. **Actuators**

1. All actuators requiring greater than 150 inch/pounds of torque shall be provided as pneumatic actuators as defined below.
2. Ambient Operating Temperature Limits: -10 to 150°F (-12.2 to 66 °C)
3. **Two Position Electric Actuators:** Line voltage (120 volt, 24 volt) with spring return. Provide end switches as required.
4. **Pneumatic Actuators:** Provide heavy-duty actuators with stroke indication and spring return. Actuator shall consist of steel or aluminum cylinder and pistons. Housing shall be protected both internally and externally with corrosion resistant coating. Provide position feedback positive positioners with adjustable start point and operating range. Positive Positioners shall be provided on all pneumatic valves larger than 1".
5. **Electronic Actuators:** Provide actuators with spring return for two-position (24v), 0-5 Vdc, 0-10 Vdc, 2-10Vdc, 4-20 mA, or network connection as required. Actuators shall travel full stroke in less than 90 seconds (VAV terminal box actuators may be up to 300 second full stroke time). Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed. Provide stroke indicator. Actuators shall have positive positioning circuit. When two non-networked actuators are required to operate in parallel, or in sequence, provide an auxiliary actuator driver. Actuators shall have current limiting motor protection. Actuators shall have manual override. Modulating actuators for valves shall have minimum rangeability of 40 to 1.
 - a) **Close-Off Pressure:** Provide the minimum torque required, and spring return for fail positioning (unless otherwise specifically indicated) sized for required close-off pressure. Required close-off pressure for two-way water valve applications shall be the shutoff head of associated pump. Required close-off rating of steam valve applications shall be design inlet steam pressure plus 50

percent for low pressure steam, and 10 percent for high pressure steam. Required close-off rating of air damper applications shall be shutoff pressure of associated fan, plus 10 percent.

- b) **Acceptable Manufacturers:** Subject to compliance with requirements approved manufacturers are as follows:
 - 1) Siemens
 - 2) **Schneider Electric**-TAC DuraDrive
 - 3) Belimo
 - 4) Johnson Controls
 - 5) Delta
 - 6) **Substitutions:** As provided under {*Insert applicable Specification Sections*}

C. Quarter-Turn Actuators (for ball valves):

1. Electric

- a) **Motor:** Suitable for 24, 120 or 240 Volt single-phase power supply. Insulation shall be NEMA Class F or better. Motor shall be rated for 100 percent duty cycle. Motors shall have inherent overload protection.
- b) **Gear Train:** Motor output shall be directed to a self locking gear drive mechanism. Gears shall be rated for torque input exceeding motor locked rotor torque.
- c) **Wiring:** Power and control wiring shall be wired to a terminal strip in the actuator enclosure
- d) **Failsafe Positioning:** Actuators shall be spring return type for failsafe positioning. {*Consult with Owner regarding application of fail safe actuators*}
- e) **Enclosure:** Exterior actuator enclosure shall be a NEMA-4 epoxy coated metal enclosure, and shall have a minimum of two threaded conduit entries.
- f) **Limit Switches:** Travel limit switches shall be UL and UNC approved. Switches shall limit actuator in both open and closed positions.
- g) **Mechanical Travel Stops:** The actuator shall include mechanical travel stops of stainless steel construction to limit actuator to specific degrees of rotation.
- h) **Manual Override:** Actuators shall have manual actuator override to allow operation of the valve when power is off. For valves 4 inches and smaller the override may be a removable wrench or lever or geared handwheel type. For larger than 4" valves, the override shall be a fixed geared handwheel type. An automatic power cut-off switch shall be provided to disconnect power from the motor when the handwheel is engaged for manual operation.
- i) **Valve Position Indicator:** A valve position indicator with arrow and open and closed position marks shall be provided to indicate valve position.
- j) **Torque Limit Switches:** Provide torque limit switches to interrupt motor power when torque limit is exceeded in either direction of rotation.

- k) **Position Controller:** For valves used for modulating control, provide an electronic positioner capable of accepting 4-20 mA, 0-10 Vdc, 2-10 Vdc, and 135 Ohm potentiometer.
 - l) **Ambient Conditions:** Actuator shall be designed for operation from -140 to 150 °F ambient with 0 to 100 percent relative humidity.
2. **Pneumatic Single- and Double-Acting Cylinder Type:**
- a) **Air Cylinder:** Shall consist of steel or aluminum cylinder, dual pistons, double rack and pinion gearing mechanism. Housing shall be protected both internally and externally with corrosion resistant coating. Actuator shall be equipped with piston guide rods or similar mechanism so that seals are not loaded as linear bearings. Single acting units shall have multiple symmetrically arranged springs to apply equal force to piston. Cylinder shall be configurable for direction of fail-safe mode in the field. Actuators shall be spring return type for failsafe positioning.
 - b) **Position Indication:** Provide extended shaft position indicator that is removable for manual override of valve.
 - c) **Two-Position Actuators:** Provide appropriate three-way or four-way solenoid valve mounted on the actuator. Solenoid valve electrical enclosure shall meet NEMA-4 requirements. Provide actuator with position switches where required.
 - d) **Modulating Actuators:** Provide a rotary electronic positioner designed to accept 4-20 mA, 0-10 Vdc, 2-10 Vdc, 135 Ohm potentiometer, or network input and operate integral 3-way or 4-way solenoid valve to position valve rotation angle as sensed by integral position feedback device to match signal input. Enclosure shall meet NEMA-4 requirements. Actuator linearity and resolution shall be 0.5% of span. Hysteresis and deadband shall be adjustable. Provide accessory mechanical or proximity type position switches and position transmitters where required. Actuators shall be spring return type for failsafe positioning. Provide an enclosure heater for positioners located outside of buildings.

II.9 GENERAL FIELD DEVICES

- A. Provide field devices for input and output of digital (binary) and analog signals into controllers. Provide signal conditioning for all field devices as recommended by field device manufacturers, and as required for proper operation in the system.
- B. Smart sensors or smart actuators shall meet all controller requirements in addition to the relevant sensor or actuator requirements.
- C. It shall be the Contractor's responsibility to assure that all field devices are compatible with controller hardware and software.
- D. Field devices specified herein are generally 'two-wire' type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, or is not designed to work with 'two-wire' type transmitters, or if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, the Contractor shall provide 'four-wire' type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.

- E. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.
- F. **Accuracy:** As stated in this Section, accuracy shall include combined effects of nonlinearity, nonrepeatability and hysteresis.

II.10 TEMPERATURE SENSORS (TS)

- A. **Sensor range:** When matched with A/D converter of controller, sensor range shall provide a resolution of no worse than 0.3°F (0.16 °C) (unless noted otherwise). Where thermistors are used, the stability shall be better than 0.25°F over 5 years.

AE shall carefully specify other applications where matched sensors are required for the specific project.

- B. **Matched Sensors:** The following applications shall require matched sensors:
 - 1. **Hydronic Temperature Difference Calculations:** Provide matched supply and return temperature sensors where the pair is used for calculating temperature difference for use in load calculations or sequencing such as across chillers and plants. Sensing element shall be platinum RTD guaranteeing an accuracy of +/- 0.5% of span plus 0.1°C
 - 2. **Air Handling Unit Sequencing:** Provide matched pair for the cooling and heating coil leaving sensors where the sequence includes calculating an offset from the supply air setpoint to maintain a leaving heating coil temperature. Sensing element shall be platinum RTD guaranteeing an accuracy of +/- 0.5% of span plus 0.1°C

AE must designate where various amenities to room sensors are required. The following assumes that this will be indicated on the control design drawings. Otherwise AE must add the clarification below. Edit/Delete the following to suit the systems applicable.

These are sensors for standard control and monitoring. Consult UNC personnel for direction in the application of sensing element types.

- C. **Room Temperature Sensor:** Shall be an element contained within a ventilated cover, suitable for wall mounting. Provide insulated base. Following sensing elements are acceptable:
 - 1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 1.0°F accuracy at calibration point.
 - 2. Provide setpoint adjustment with initial normal setpoint 73°F and adjustable range of +/- 3°F. The setpoint adjustment shall be a warmer/cooler indication that shall be scalable via the BAS. Provide an occupancy override button on the room sensor enclosure. This shall be a momentary contact closure
 - 3. Provide current temperature indication via an LCD or LED readout.

These are sensors for critical control and monitoring. Consult UNC personnel for direction in the application of sensing element types. Designer to show on schedule.

- D. **Critical Room Temperature Sensor:** Shall be an element contained within a ventilated cover, suitable for wall mounting. Provide insulated base. Following sensing elements are acceptable:
 - 1. Sensing element shall be platinum RTD, ± 0.1 °C measured at 0 °C.

2. Provide setpoint adjustment with initial normal setpoint 73°F and adjustable range of +/- 3°F. The setpoint adjustment shall be a warmer/cooler indication that shall be scalable via the BAS.
3. Provide an occupancy override button on the room sensor enclosure. This shall be a momentary contact closure
4. Provide current temperature indication via an LCD or LED readout.

These are sensors for standard control and monitoring. Consult UNC personnel for direction in the application of sensing element types.

- E. **Single-Point Duct Temperature Sensor:** Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated in paragraph A. Sensor probe shall be 316 or 304 stainless steel.
1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.3°F accuracy at calibration point

These are sensors for critical control and monitoring. Consult UNC personnel for direction in the application of sensing element types.

- F. **Critical Single-Point Duct Temperature Sensor:** Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated in paragraph A. Sensor probe shall be 316 stainless steel.
1. Sensing element shall be platinum RTD, ± 0.1 °C measured at 0 °C.

Edit the following averaging length per square foot based on how homogeneous the air temperature will be at the installed location. For instance, a preheat sensor of a mixed air plenum will require more length than the discharge off a preheat coil in a 100% OA unit.

These are sensors for standard control and monitoring. Consult UNC personnel for direction in the application of sensing element types.

- G. **Averaging Duct Temperature Sensor:** Shall consist of an averaging element, junction box for wiring connections and gasket to prevent air leakage. Provide sensor lengths and quantities to result in one lineal foot of sensing element for each three square feet of cooling coil/duct face area. Temperature range as required for resolution indicated in paragraph A.
1. Sensing element shall be platinum RTD, or thermistor, +/- 0.3°F accuracy at calibration point.

These are sensors for critical control and monitoring. Consult UNC personnel for direction in the application of sensing element types.

- H. **Critical Averaging Duct Temperature Sensor:** Shall consist of an averaging element, junction box for wiring connections and gasket to prevent air leakage. Provide sensor lengths and quantities to result in one lineal foot of sensing element for each three square feet of cooling coil/duct face area. Temperature range as required for resolution indicated in paragraph A.
1. Sensing element shall be platinum RTD, ± 0.2 °C measured at 0 °C.
- I. **Liquid Immersion Temperature Sensor** shall include brass thermowell, sensor and connection head for wiring connections. Temperature range shall be as required for resolution of 0.15°F.

1. Sensing element (chilled water/glycol systems) shall be thermistor or platinum RTD ± 0.3 °C measured at 0 °C.
- J. **Pipe Surface-Mount Temperature Sensor:** Shall include metal junction box and clamps and shall be suitable for sensing pipe surface temperature and installation under insulation. Provide thermally conductive paste at pipe contact point. Temperature range shall be as require for resolution indicated in paragraph A.
 1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, ± 0.4 °F accuracy at calibration point.
- K. **Outside Air Sensor:** Shall consist of a sensor, sun shield, utility box, and watertight gasket to prevent water seepage. Temperature range shall be as require for resolution indicated in Paragraph A
- L. Sensing element shall be platinum RTD, thermistor, or integrated circuit, sensor range shall provide a resolution of no worse than ± 0.1 °C measured at 10 °C.

II.11 HUMIDITY TRANSMITTERS

- A. Units shall be suitable for duct, wall (room) or outdoor mounting. Unit shall be two-wire transmitter utilizing bulk polymer resistance change or thin film capacitance change humidity sensor. Unit shall produce linear continuous output of 4-20 mA for percent relative humidity (% RH). A combination temperature and humidity sensor may be used for zone level monitoring. Sensors shall have the following minimum performance and application criteria:
 1. Input Range: 0 to 100% RH.
 2. Accuracy(% RH): $\pm 2\%$ (when used for outside air, enthalpy calculation, dewpoint calculation or humidifier control) or $\pm 3\%$ (monitoring only) between 20-90% RH at 77°F, including hysteresis, linearity, and repeatability.
 3. Sensor Operating Range: As required by application
 4. Long Term Stability: Less than 1% drift per year.
- B. **Acceptable Manufacturers:** Units shall be Vaisala HM Series, General Eastern, Microline, or Hy-Cal HT Series. Substitutions shall be allowed per Division 1.

II.12 DIFFERENTIAL PRESSURE TRANSMITTERS (DP)

AE shall consult with UNC personnel prior to specifying DP Transmitters.

- A. **Hot Water General Purpose:**
 1. **General:** Two wire transmitter, 4-20 mA or 0-5 volt for runs less than 100' output with zero and span adjustments.
 2. **Ambient Limits:** -40 to 175 °F (-40 to 121°C), 0 to 100% RH.
 3. **Process limits:** -40 to 250 °F
 4. **Accuracy:** 0.5% overall accuracy,
 5. **Maximum Pressure Rating:** 450 psig (3103 KPa) maximum static pressure rating, 200 psid maximum overpressure rating for 6 through 60 psid range, 450 psid for 100 through 300 psid range.
 6. Kele & Associates Model 360 C, Substitutions per Div 1.
- B. **Hot Water Critical Service:**

1. **General:** Two-wire smart DP cell type transmitter, 4-20 mA or 0-5 Vdc user-selectable linear or square root output, adjustable span and zero, stainless steel wetted parts.
 2. **Ambient Limits:** -40 to 175 °F (-40 to 121°C), 0 to 100% RH.
 3. **Process limits:** -40 to 400 °F (-40 to 205°C).
 4. **Accuracy:** less than 0.1%
 5. **Output Damping:** Time constant user selectable from 0 to 36 seconds
 6. **Vibration Effect:** Less than $\pm 0.1\%$ of upper range limit from 15 to 2000 Hz in any axis relative to pipe mounted process conditions.
 7. **Electrical Enclosure:** NEMA-4, -4X, -7, -9.
 8. **Approvals:** FM, CSA.
 9. **Acceptable Manufacturers:** Rosemount Inc. 3051 Series, Foxboro, Johnson-Yokagawa. Substitutions shall be allowed per Division 1.
- C. **General Purpose Low Pressure Air:** Generally for each measurement of duct pressure, filter differential pressure or constant volume air velocity pressure measurement where the range is applicable.
1. **General:** Loop powered two-wire differential capacitance cell-type transmitter.
 2. **Output:** two wire 4-20 mA or 0-5 volt for runs less than 100' output with zero adjustment.
 3. **Overall Accuracy:** Plus or minus 1%.
 4. **Minimum Range:** 0.1 in. w.c.
 5. **Maximum Range:** 10 inches w.c.
 6. **Housing:** Polymer housing suitable for surface mounting.
 7. **Acceptable Manufacturers:** Units shall be Modus T30, Veris PX Series, or Dwyer Series 616. Substitutions shall be allowed per Division 1.
 8. **Static Sensing Element:** Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
 9. **Range:** Select for specified setpoint to be between 25% and 75% full-scale.
- D. **General Purpose Low Pressure/Low Differential Air:** Generally for use in static measurement of space pressure or constant volume air velocity pressure measurement where the range is applicable.
1. **General:** Loop powered, two-wire differential capacitance cell type transmitter.
 2. **Output:** Two-wire 4-20 mA or 0-5 volt for runs less than 100' output with zero adjustment.
 3. **Overall Accuracy:** Plus or minus 1%.
 4. **Minimum Repeatability:** $\pm .25\%$ of reading
 5. **Maximum Range:** 0.1, 0.25, or 0.5 inches w.c.
 6. **Housing:** Polymer housing suitable for surface mounting.
 7. **Acceptable Manufacturers:** Modus T30. Substitutions shall be allowed per Division 1.
 8. **Static Sensing Element:** Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
 9. **Range:** Select for specified setpoint to be between 25% and 75% full-scale.

- E. **VAV Velocity Pressure:** Generally for use in variable volume air velocity pressure measurement where the range is applicable.
1. **General:** Loop powered two-wire differential capacitance cell type transmitter.
 2. **Output:** Two-wire, 4-20 mA output with zero adjustment.
 3. **Overall Accuracy:** Plus or minus 0.25%
 4. **Minimum Range:** 0 in. w.c.
 5. **Maximum Range:** 1 inch w.c.
 6. **Housing:** Polymer housing suitable for surface mounting.
 7. **Acceptable Manufacturers:** Setra. Substitutions shall be allowed per Division 1.
 8. **Range:** Select for minimum range that will accept the maximum velocity pressure expected.

II.13 AIRFLOW MEASURING STATIONS (AFMS)

- A. Fan Inlet Probe: Shall consist of vortex shedding multi-sensor probes which are installed in the inlet of the fan. Individual sensor transmitters on the probe provide direct proportional and linear signals to airflow velocity.
1. Sensor Accuracy: $\pm 2.0\%$
 2. Interchangeability: $\pm 0.5\%$
 3. Velocity Range: 750 to 9000 fpm (*Designer to verify required range.*)
 4. Electronics Accuracy: $\pm 0.05\%$
 5. Temperature Limits: -20°F to 140°F
 6. Enclosure for Electronics: NEMA 1
 7. Material: Aluminum
 8. Operating Range: Select minimum range to accommodate the expected flow range of the equipment
 9. Acceptable Manufacturer: Tek-Air Systems Inc. 'Vortek' Model 7000, or Approved Equal.
- B. Air Flow Traverse Probes: Furnish where indicated on the drawings, vortex shedding multi-sensor insertion type, air flow traverse probes. The probes, and placement of the probes, shall provide measurement accuracy within $\pm 2\%$ of actual velocity. Probes shall be of cylindrical cross section and shall indicate no more than a $\pm 3\%$ deviation from the centerline velocity at a yaw angle of 30 degrees. Probes shall be 304 stainless steel. Probes shall be provided with integral mounting plate, $\frac{1}{4}$ compression fitting connections, end mounting rod and be suitable to operate in ambient conditions off 300°F . The probe assemblies shall not have a pressure drop greater than 10% of the velocity pressure at the maximum design flow. The probes shall not amplify sound levels in the duct. Submit data indicating the developed differential pressure and pressure loss at the minimum and maximum design flows for each duct location. Provide differential pressure transmitter for measuring velocity, with a range selected to match the velocity of the maximum design flow for the duct served. MDE to provide rigid section with straight section meeting upstream and downstream requirements using air flow straighteners as needed and will verify transducer range.
1. Sensor Accuracy: $\pm 2.0\%$
 2. Interchangeability: $\pm 0.5\%$

3. Velocity Range: 400 to 9000 fpm
4. Electronics Accuracy: $\pm 0.05\%$
5. Temperature Limits: -20°F to 200°F
6. Enclosure for Electronics: NEMA 1
7. Humidity Limits: 0 to 100% RH (non-condensing)
8. Material: 304 stainless steel
9. Operating Range: Select minimum range to accommodate the expected flow range of the equipment

The following schedule is the minimum probe quantities across either the width or height of the duct sections where the probes are being inserted:

<u>Insertion side</u>	<u>Qty</u>
6-11 inches	1
12-30 inches	2
31-48 inches	3
48-60 inches	4
61-84 inches	6
85-120 inches	6

10. Manufacturer: Tek-Air Systems Inc. 'Vortek' Model 5000, or Approved Equal.

II.14 VALVE BYPASS FOR DIFFERENTIAL PRESSURE SENSORS

- A. Provide a five valve bypass kit for protection of DP sensors where the static on the pipe can cause an over pressure when connected to one port with the other at atmospheric pressure. Kit shall include high and low pressure isolation valves, high and low pressure vent valves, calibration taps, and a bypass valve contained in a NEMA-1 enclosure.

II.15 DIFFERENTIAL PRESSURE SWITCHES (DPS)

- A. **General Service Auto Reset - Air:** Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing. Acceptable Manufacturer - Dwyer Series 1900 or equal.
- B. **General Service Manual Reset - Air:** Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing. Acceptable Manufacturer - Dwyer Series 1900 or equal.
- C. **General Service - Water:** Diaphragm with adjustable setpoint, 2 psig or adjustable differential and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range and 0°F to 160°F operating temperature range.

II.16 PRESSURE SWITCHES (PS)

- A. Diaphragm or bourdon tube with adjustable setpoint and differential and snap-acting Form C contacts rated for the application. Pressure switches shall be capable of withstanding 150% of rated pressure.
- B. **Acceptable Manufacturers:** Square D, ITT Neo-Dyn, ASCO, Penn, Honeywell, and Johnson Controls. Substitutions shall be allowed per Division 1.

II.17 TRANSDUCERS

Consult UNC personnel for direction in the application of Transducers.

- A. **Standard Capacity Electronic-to-Pneumatic (E-P) Transducers:** E-P transducers shall be Voltage-to-Pneumatic (V-P) type, Current-to-Pneumatic (I-P) type:
1. **Electrical Power Supply:** 24 Vac or 24 Vdc.
 2. **Pneumatic Air Supply:** 30 psig (2.07 bar) maximum.
 3. **Air Capacity:** 1100 scim @ 20 psig (300 cm³/sec @ 1.4 bar).
 4. **Air Consumption:** Zero at steady state.
 5. **Output Span:** 0-20 psig (0-1.4 bar).
 6. **Input:** 4-20 mA, 0-5 Vdc, 1-5 Vdc, 0-10 Vdc, 2-10 Vdc, 0-15 Vdc, or 3-15 Vdc input.
 7. **Filter:** Provide inline filter at the main air connection to remove oil, moisture and dirt with an indicator for contamination.
 8. **Gauges:** Provide with main and branch air gauges
 9. **Enclosure:** Polymer designed for surface or panel mount. Provide with main air and branch air gauges.
 10. **Air Connections:** 1/4" (6.35 mm) barbed.
 11. **Failure Mode on Power Loss:** Non-failsafe transducers shall have no output air loss. Failsafe transducers shall exhaust output upon power loss.
 12. **Acceptable Manufacturers:** RE Technologies Model UCP-522. Substitutions shall be allowed per Division 1.

Consult UNC personnel for direction in the application of Transducers.

- B. **Electronic-to-Pneumatic (E-P) Transducers:** E-P transducers shall be Voltage-to-Pneumatic (V-P) type, Current-to-Pneumatic (I-P) type, Phase cut Type:
1. **Electrical Power Supply:** 24 Vac or 24 Vdc, 100 mA.
 2. **Accuracy:** +- 1%
 3. **Feedback:** Branch pressure feedback from an on board pressure sensor - VDC Feedback
 4. **Override:** Manual Potentiometer
 5. **Pneumatic Air Supply:** 25-30 psig (2.07 bar) maximum.
 6. **Air Capacity:** .5 scim @ 20 psig (300 cm³/sec @ 1.4 bar).
 7. **Air Consumption:** None
 8. **Output Span:** 3-15 psig factory set field adjustable
 9. **Input:** 4-20 mA, 0-5 Vdc, 0-10 Vdc, 2-10 Vdc, 0-18 Vdc, 0-20V Phase Cut input.
 10. **Filter:** Provide inline filter at the main air connection to remove oil, moisture and dirt with an indicator for contamination.
 11. **Gauges:** Provide with main and branch air gauges
 12. **Enclosure:** NEMA 1. Provide with main air and branch air gauges.
 13. **Air Connections:** 1/4" (6.35 mm) barbed brass.
 14. **Failure Mode on Power Loss:** Non-failsafe transducers shall have no output air loss. Failsafe transducers shall exhaust output upon power loss.

15. **Acceptable Manufacturers:** TRIATEK CP-3000 Substitutions shall be allowed per Division 1.

II.18 CURRENT SWITCHES (CS)

- A. **Clamp-On or Solid-Core Design Current Operated Switch** (for Constant Speed Motor Status Indication)
 1. **Range:** 1.5 to 150 amps.
 2. **Trip Point:** Adjustable.
 3. **Switch:** Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage.
 4. **Lower Frequency Limit:** 6 Hz.
 5. **Trip Indication:** LED
 6. **Approvals:** UL, CSA
 7. **Max. Cable Size:** 350 MCM
 8. **Acceptable Manufacturers:** Veris Industries H-708/908; Inc., RE Technologies SCS1150A-LED. Substitutions shall be allowed per Division 1.
- B. **Clamp-on or Solid-Core Wire Through Current Switch (CS/CR) (for Constant Speed Motors):** Same as CS with 24v command relay rated at 5A @ 240 Vac resistive, 3A @ 240 Vac inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A). Acceptable Manufacturers shall be Veris Industries, Inc., Model # H938/735; or RE Technologies RCS 1150. Substitutions shall be allowed per Division 1.
 1. Where used for single-phase devices, provide the CS/CR in a self-contained unit in a housing similar with override switch to Kele RIBX. Substitutions shall be allowed per Division 1.
- C. **Clamp-On Design Current Operated Switch for Variable Speed Motor Status Indication**
 1. **Range:** 1.5 to 135 Amps.
 2. **Trip Point:** Self-calibrating based on VA memory associated with frequency to detect loss of belt with subsequent increase of control output to 60 Hz.
 3. **Switch:** Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage.
 4. **Frequency Range:** 5-75 Hz
 5. **Trip Indication:** LED
 6. **Approvals:** UL, CSA
 7. **Max. Cable Size:** 350 MCM
 8. **Acceptable Manufacturers:** Veris Industries, Inc. H-904. Substitutions shall be allowed per Division 1.
- D. **Clamp-On Wire Through Current Switch (CS/CR) (for Variable Speed Motors):** Same as CS with 24v command relay rated at 5A @ 240 Vac resistive, 3A @ 240 Vac inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A). Acceptable manufacturer shall be Veris Industries, Inc., Model # H934. Substitutions shall be allowed per Division 1.

- E. **Variable Speed Status:** Where current switches are used to sense the status for variable speed devices, the CT shall include on-board VA/Hz memory to allow distinction between a belt break and subsequent ramp up to 60 Hz, versus operation at low speed. The belt break scenario shall be indicated as a loss of status and the operation at low speed shall indicate normal status.

II.19 CURRENT TRANSFORMERS (CT)

A. Clamp-On Design Current Transformer (for Motor Current Sensing)

1. **Range:** 1-10 amps minimum, 20-200 amps maximum
2. **Trip Point:** Adjustable
3. **Output:** 0-5 VDC.
4. **Accuracy:** $\pm 0.2\%$ from 20 to 100 Hz.
5. **Acceptable Manufacturers:** Veris H221 and KELE SA100. Substitutions shall be allowed per Division 1.

II.20 OUTDOOR AIR STATIC PRESSURE SENSING TIP

- A. **Pressure sensor:** Pressure sensing tip shall be designed to minimize the effects of wind and resulting velocity pressure up to 80 mph. Acceptable manufacturers shall be Dwyer A-306. Substitutions shall be allowed per Division 1.
- B. **Low Air Pressure Surge Dampener:** 30-second time constant. Acceptable manufacturer shall be Modus SD030. Substitutions shall be allowed per Division 1.

II.21 INSERTION TYPE TURBINE METER FOR WATER SERVICE

- A. Turbine Insertion Flow Meter sensing method shall be impedance sensing (iron magnetic and non-photoelectric), with volumetric accuracy of $\pm 2\%$ of reading over middle 80% of operating range, and $\pm 4\%$ of reading over the entire operating range. Turbine Insertion Flow Meter shall have maximum operating pressure of 400 psi and maximum operating temperature of 200°F continuous (220°F peak). All wetted metal parts shall be constructed of 316 stainless steel. Flow meter shall meet or exceed all of the accuracy, head loss, flow limits, pressure and material requirements of the AWWA standard C704-70 for the respective pipe or tube size. Analog outputs shall consist of non-interactive zero and span adjustments, a DC linearity of 0.1% of span, voltage output of 0-10 V, and current output of 4-20 mA.
1. Install in water systems with a minimum of 10 pipe diameters unobstructed flow. Double turbine insertion required at between 10 and 4 diameters unobstructed flow.
 2. Acceptable Manufacturers: Onicon Corp. and Hersey. Substitutions shall be allowed per Division 1.

II.22 CO₂ SENSORS/TRANSMITTERS (CO₂)

- A. CO₂ sensors shall use silicon based, diffusion aspirated, infrared single beam, dual-wavelength sensor.
- B. **Accuracy:** ± 36 ppm at 800 ppm and 68°F.
- C. **Stability:** 5% over 5 years.

- D. **Output:** 4-20 mA, 0-10 Vdc or relay.
- E. **Mounting:** Duct or Wall as indicated.
- F. **Calibration Kit** – Kit shall include 2 17 liter Co2 calibration gas cylinders; one 200 ppm and one 1000 ppm, gas regulator, tubing, and fittings, adapters, sensor cones etc. for the application.
- G. **Acceptable Manufacturer:** Vaisala, Inc. GMD20 (duct) or GMW20 (wall).

II.23 PNEUMATIC CONTROL COMPONENTS

- A. **Analog Pressure Gauges:** Gauges shall be pneumatic type, minimum 1-1/2" in (38 mm) diameter, with white face and black numerals. Surface-mounted gauges shall have chrome plated trim and be a minimum of 2-1/2" in (64 mm) diameter.
- B. **Pneumatic Actuated Pressure Switches (PE)** (for 30 psig max pressure control systems): Pressure ranges and sensitivity of PEs shall match control system sequence of operation. Switch operation shall be externally adjustable over the operating pressure range (nominal 0-20 psig, 0 to 138 KPa). PE switches shall be SPDT type, rated for the particular application, and shall be UL listed. PE shall be as manufactured by Penn. Substitutions shall be allowed as per Division 1
- C. **Pilot Positioners:** Operating span adjustment range is from 3 to 15 psi (21 to 104 kPa), or as required for the actuator being served. Positioner shall be furnished with zero and span adjustments and a mounting bracket for attachment directly to the actuator.

II.24 ELECTRIC CONTROL COMPONENTS

- A. **Limit Switches (LS):** Limit switches shall be UL listed, SPDT or DPDT type, with adjustable trim arm. Limit switches shall be as manufactured by Square D, Allen Bradley. Substitutions shall be allowed per Division 1.
- B. **Electric Solenoid-Operated Pneumatic Valves (EP):** EP valves shall be rated for a minimum of 1.5 times their maximum operating static and differential pressure. Valves shall be ported 2-way, 3-way, or 4-way and shall be normally closed or open as required by the application. EPs shall be sized for minimum pressure drop, and shall be UL and CSA listed. Furnish and install gauges on all inputs of EPs. Furnish an adjustable air pressure regulator on input side of solenoid valves serving actuators operating at greater than 30 psig.
 - 1. **Coil Enclosure:** Indoors shall be NEMA-1, Outdoors and NEMA-3, 4, 7, 9.
 - 2. **Fluid Temperature Rating:** Valves for compressed air and cold water service shall have 150 °F (66 °C) minimum rating. Valves for hot water or steam service shall have fluid temperature rating higher than the maximum expected fluid temperature.
 - 3. **Acceptable Manufacturers:** EP valves shall be as manufactured by ASCO or Parker. Substitutions shall be allowed per Division 1.
 - 4. **Coil Rating:** EP valves shall have appropriate voltage coil rated for the application (i.e., 24 VAC, 120 VAC, 24 VDC, etc.).
- C. **Low Temperature Detector ('Freezestat') (FZ):** Low temperature detector shall consist of a 'cold spot' element which responds only to the lowest temperature along any one foot of entire element, minimum bulb size of 1/8" x 20' (3.2mm x 6.1m), junction box for wiring connections and gasket to prevent air leakage or vibration noise, DPDT (4

wire, 2 circuit) with manual reset. Temperature range 15 to 55°F (-9.4 to 12.8°C), factory set at 38°F.

- D. **High Temperature Detectors ('Firestat') (FS):** High temperature detector shall consist of 3-pole contacts, a single point sensor, junction box for wiring connections and gasket to prevent air leakage of vibration noise, triple-pole, with manual reset. Temperature range 25 to 215°F (-4 to 102°C).
- E. **Surface-Mounted Thermostat:** Surface-mounted thermostat shall consist of SPDT contacts, operating temperature range of 50 to 150° F (10 to 65°C) , and a minimum 10°F fixed setpoint differential.
- F. **Low Voltage Wall Thermostat:** Wall-mounted thermostat shall consist of SPDT sealed contacts, operating temperature range of 50 to 90°F (10 to 32°C), switch rating of 24 Vac (30 Vac max.), and both manual and automatic fan operation in both the heat and cool modes.
- G. **Control Relays:** All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA-1 enclosure for indoor locations, NEMA-4 for outdoor locations.
1. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
 - a) AC coil pull-in voltage range of +10%, -15% or nominal voltage.
 - b) Coil sealed volt-amperes (VA) not greater than four (4) VA.
 - c) Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
 - d) Pilot light indication of power-to-coil and coil retainer clips.
 - e) Coil rated for 50 and 60 Hz service.
 - f) **Acceptable Manufacturers:** Relays shall be Potter Brumfield, Model KRPA. Substitutions shall be allowed per Division 1.
 2. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load. Relays shall be IDEC. Substitutions shall be allowed per Division 1.
 3. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.
 4. All safety circuits shall be installed to operate individual interposing relays located in the associated equipment control panel. Each safety device (i.e. Freezestat, DP safety, smoke detector, firestat, etc.) wiring circuit shall be installed with individual homeruns back to the associated control panel. See control drawings for details.
- H. **General Purpose Power Contactors:** NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA type 1 enclosure. Manufacturer shall be Square 'D', Cutler-Hammer or Westinghouse.
- I. **Control Transformers:** Furnish and install control transformers as required. Control transformers shall be machine tool type, and shall be US and CSA listed. Primary and secondary sides shall have replaceable fuses in accordance with the NEC. Transformer shall be proper size for application, and mounted in minimum NEMA-1 enclosure.

1. Transformers shall be manufactured by Westinghouse, Square 'D', or Jefferson. Substitutions shall be allowed per Division 1.
- J. **Time Delay Relays (TDR):** TDRs shall be capable of on or off delayed functions, with adjustable timing periods, and cycle timing light. Contacts shall be rated for the application with a minimum of two (2) sets of Form C contacts, enclosed in a dustproof enclosure.
 1. TDRs shall have silver cadmium contacts with a minimum life span rating of one million operations. TDRs shall have solid state, plug-in type coils with transient suppression devices.
 2. TDRs shall be UL and CSA listed, Crouzet type. Substitutions shall be allowed per Division 1.
- K. **Electric Push Button Switch:** Switch shall be momentary contact, oil tight, push button, with number of N.O. and/or N.C. contacts as required. Contacts shall be snap-action type, and rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen Bradley. Substitutions shall be allowed per Division 1.
- L. **Pilot Light:** Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC. Unit shall be 800T type, as manufactured by Allen-Bradley. Substitutions shall be allowed per Division 1.
- M. **Alarm Horn:** Panel-mounted audible alarm horn shall be continuous tone, 120 Vac Sonalert solid-state electronic signal, as manufactured by Mallory. Substitutions shall be allowed per Division 1.
- N. **Electric Selector Switch (SS):** Switch shall be maintained contact, NEMA ICS 2, oil-tight selector switch with contact arrangement, as required. Contacts shall be rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen-Bradley. Substitutions shall be allowed per Division 1.

II.25 NAMEPLATES

- A. Provide engraved phenolic or micarta nameplates for all equipment, components, and field devices furnished. Nameplates shall be 1/8 thick, black, with white center core, and shall be minimum 1" x 3", with minimum 1/4" high block lettering. Nameplates for devices smaller than 1" x 3" shall be attached to adjacent surface.
- B. Each nameplate shall identify the function for each device.
- C. Provide nameplates riveted to ceiling grid for terminal equipment or controllers located above accessible ceilings.

II.26 TESTING EQUIPMENT

- A. Contractor shall test and calibrate all signaling circuits of all field devices to ascertain that required digital and accurate analog signals are transmitted, received, and displayed at system operator terminals, and make all repairs and recalibrations required to complete test. Contractor shall be responsible for test equipment required to perform these tests and calibrations. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range).

PART III. EXECUTION

III.1 INSPECTION

- A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

III.2 INSTALLATION OF CONTROL SYSTEMS

- A. **General:** Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings. Install electrical components and use electrical products complying with requirements of National Electric Code and all local codes.
- B. **Main Control Air Piping:** All main air piping between the compressors and the control panels shall be copper, run per ASTM B88
- C. **Branch Control Air Piping:** Accessible tubing is defined as that tubing run in mechanical equipment rooms; inside mechanical equipment enclosures, such as heating and cooling units, instrument panels; across roofs, in pipe chases, etc. Inaccessible tubing is defined as that tubing run in concrete slabs; furred walls; or ceilings with no access.
 - 1. Provide copper tubing with maximum unsupported length of 3'-0", for accessible tubing run exposed to view. Terminal single-line connections less than 18 in length may be copper tubing, or polyethylene tubing. Tubing exposed to ambient conditions must be properly protected from sunlight and protected from damage.
 - 2. Provide copper tubing for inaccessible tubing, other than in concrete pour. In a concrete pour polyethylene tubing may be used, install in rigid conduit or PVC pipe.
 - 3. Polyethylene tubing may be used in control panels provided it is run in a neat and orderly fashion, bundled where applicable, properly supported and installed in a neat and workman like manner. Fasten flexible connections bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support tubing neatly.
 - 4. Pressure test control air piping at 30 psi (207 kPa) for 24 hours. Test fails if more than 2 psi loss occurs. Owner shall witness pressure test and Contractor shall document test with witness signature.
 - 5. Fasten flexible connections bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support tubing neatly.
 - 6. Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.
- D. **Control Wiring:** The term "control wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connection of electric control devices.

1. **Wiring System:** Install complete wiring system for electric control systems. Conceal wiring except in mechanical rooms and areas where other conduit and piping are exposed. Installation of wiring shall generally follow building lines. Install in accordance with National Electrical Code and Division 16 of this Specification. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.
2. **Control Wiring Conductors:** Install control wiring conductors, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code and Division 16 of this Specification.
3. Communication wiring, signal wiring and low voltage control wiring shall be installed separate from any wiring over thirty (30) volts. Signal wiring shield shall be grounded at controller end only, unless otherwise recommended by the controller manufacturer.
4. All control network wiring shield shall be terminated as recommended by controller manufacturer. All control network wiring shall be labeled with a network number, NodeID at each termination and shall correspond with the network architecture and floor plan submittals.
5. Install all control wiring external to panels in electric metallic tubing or raceway. Installation of wiring shall generally follow building lines. Provide compression type connectors. Provide rigid conduit at all exterior locations and where subjected to moisture. All conduits penetrating partitions, walls or floors shall be sealed with a submitted and approved non-hardening putty material to prevent migration of air through the conduit system. *However, communication wiring, signal wiring and low voltage control wiring may be run without conduit in concealed, accessible locations if noise immunity is ensured. Contractor will be fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance. Accessible locations are defined as areas inside mechanical equipment enclosures, such as heating and cooling units, instrument panels etc.; in accessible pipe chases with easy access, or suspended ceilings with easy access. Installation of wiring shall generally follow building lines. Run in a neat and orderly fashion, bundled where applicable, and completely suspended (strapped to rigid elements or routed through wiring rings) away from areas of normal access. Tie and support conductors neatly with suitable nylon ties. Conductors shall not be supported by the ceiling system or ceiling support system. Conductors shall be pulled tight and be installed as high as practically possible in ceiling cavities. Wiring shall not be laid on the ceiling or duct. Conductors shall not be installed between the top cord of a joist or beam and the bottom of roof decking. Contractor shall be fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance. {Verify whether plenum cable runs allowed per local/state codes; notify Owner}*
6. Communication cabling shall be provided in an UNC approved color dedicated to the BAS.
7. Number-code or color-code conductors appropriately for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

- E. **Control Valves:** Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, install with valve stem axis vertical, with operator side up. Where vertical stem position is not possible, or would result in poor access, valves may be installed with stem horizontal. Do not install valves with stem below horizontal, or down.
- F. **Room Temperature Sensors:** Mount 48" above finished floor.
- G. **Critical Room Temperature Sensors:** Mount 48" above finished floor.
- H. **Averaging Temperature Sensors:** Cover no more than two square feet per linear foot of sensor length except where indicated. Generally where flow is sufficiently homogeneous/adequately mixed at sensing location, consult AE for requirements.

AE must specifically show locations of all flow measuring stations and flow meters and design the straight length of duct of pipe required for accurate sensors. This length must be specifically shown on the drawing and be adequate for the installation.

- I. **Airflow Measuring Stations:** Install per manufacturer's recommendations in an unobstructed straight length of duct (except those installations specifically designed for installation in fan inlet). For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFM station manufacturer.

AE must specifically show locations of all flow measuring stations and flow meters and design the straight length of duct of pipe required for accurate sensors. This length must be specifically shown on the drawing and be adequate for the installation.

- J. **Fluid Flow Sensors:** Install per manufacturer's recommendations in an unobstructed straight length of pipe.
- K. **Relative Humidity Sensors:** Provide element guard as recommended by manufacturer for high velocity installations. For high limit sensors, position remote enough to allow full moisture absorption into the air stream before reaching the sensor.

AE must specifically show locations of all transmitters for proper control. These devices must be specifically shown on the drawing and be adequate for the installation.

- L. **Water Differential Pressure Transmitters:** Provide valve bypass arrangement to protect against over pressure damaging the transmitter.

AE must specifically show locations of all transmitters for proper control. These devices must be specifically shown on the drawing and be adequate for the installation.

- M. **Pipe Surface Mount Temperature Sensors:** Pipe Surface Mount temperature sensor shall be installed with thermally conductive paste at pipe contact point. Where sensor is to be installed on an insulated pipe Contractor shall neatly cut insulation install sensor, repair or replace insulation and vapor barrier and adequately seal vapor barrier.
- N. **Flow Switches:** Where possible, install in a straight run of pipe at least 15 diameters in length to minimize false indications.
- O. **Current Switches for Motor Status Monitoring:** Adjust so that setpoint is below minimum operating current and above motor no load current.
- P. **Supply Duct Pressure Transmitters:**

1. **General:** Install pressure tips with at least 4 'round equivalent' duct diameters of straight duct with no takeoffs upstream. Install static pressure tips securely fastened with tip facing upstream in accordance with manufacturer's installation instructions. Locate the transmitter at an accessible location to facilitate calibration.

AE must specifically show locations of all transmitters for proper control. These devices must be specifically shown on the drawing and be adequate for the installation.

2. **VAV System 'Down-Duct' Transmitters:** Locate pressure tips approximately 3/4 of the hydraulic distance to the most remote terminal in the air system where shown on the drawings.
- Q. **Cutting and Patching Insulation:** Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

*For Critical Service Control Valve applications, Engineer shall complete the applicable following forms for each individual application and/or valve. Control valve sizing and selection is the initial responsibility of the Engineer and NOT left to the controls subcontractor. The items noted with a * and **, ** shall be completed by the Engineer to list the requirements of the valves for Cv, close off, temperature ratings, cage material, seat material, trim material etc. for each individual application. This should be a result of analyzing the valves performance and application across the range of control. Engineer shall consult with Owner prior to specifying these valves.*

UNC MASTER SPECIFICATION											
Steam Control Valve Specification Sheet (Globe Body)											
Project Name			Revisions				SHEET		xx of xx		
			NO.	BY	DATE	DESCRIPTION	SPEC. NO.		REVISION		
			1				230901		*		
			2				CONTRACT		DATE		
			3				X		mm/dd/yy		
			4				PROJECT NUMBER				
			5				XXXX.XX				
			6				BY	CHECKED	APPROVED		
			7				XYZ	XYZ	XYZ		
GENERAL	Tag Number		*								
	Service Description		*								
	P&ID Sheet Number		*								
	Line No. or Vessel No.		*								
	Line Size / Mat'l / Sch.		*								
	Electrical Class	Power Supply	*				*				
PROCESS DATA	Fluid	Fluid State	SATURATED STEAM <125 PSIG			VAPOR					
	Operating Condition		Units	Minimum	Normal	Maximum	Other				
	Flow Rate		LB/HR	*	*	*	*				
	Inlet Pressure		PSIG	*	*	*	*				
	Outlet Pressure		PSIG	*	*	*	*				
	Temperature		DEG F	*	*	*	*				
	Mol. Wt.										
	Sp. Wt	Sp. Grav									
	Viscosity	Sp Heat									
BODY	Style	Size	GLOBE				xx"				
	End Connection	Rating	xx" RF FLANGED				ANSI CLASS 150				
	Port Size	Travel	*				*				
	Valve Cv	Valve C1/Km	*				**				
	Body Matl.	Bonnet	ASTM A216 WCB				ASTM A216 WCB				
	Characteristic	Trim Number	EQUAL PERCENTAGE				* ** ,				
	Cage Matl.	Retainer Matl.	*				*				
	Seat Matl.	Seat Ring Matl.	* ** ,				* ** ,				
	Plug Matl.	Stem Matl.	* ** ,				* ** ,				
	Flow Action		DOWN								
	Gaskets		SPIRAL METALLIC								

BODY Cont.	Stem Guide		**	
	Packing		GLASS FILLED PTFE**	
	Required Seat Tightness		ANSI CLASS IV	
	Max. Allowable Sound Level (dBA)		<75 dBA	
ACTUATOR	Type		PNEUMATIC	
	Size	Bench Set	*	*
	Push-Down To	Fail Position	CLOSE*	CLOSE*
	Close At	Open At	6 PSIG*	30 PSIG*
	Handwheel		NONE*	
POSITIONER	Type		Electronic	
	Communications Protocol		*	
	Input Signal	Output Signal	4-20 mA	
	Air Supply		80 PSIG NOMINAL*	
TRANSDUCER	Type		*	
	Input Signal		*	
	Output Signal		*	
OPTIONS	Air Set w/ Gauges		YES*	
	Solenoids		*	
	Position Switches		*	
SELECTION BASED ON	Manufacturer		Fisher, Valtek, Dezurik-Copes, Leslie	
	Valve Model Number		*	
	Actuator Model No.		*	
	Positioner Model No.		*	
	Filter Regulator		YES	
NOTES	<p>*, ** Engineer to consult with and use manufacturer's recommended steam trim for the service, usually a hardened 400 series stainless steel.</p> <p>* Engineer shall fill in to suit application.</p> <p>** Vendor to confirm based on process data provided.</p>			

UNC MASTER SPECIFICATION						
Water Control Valve Specification Sheet (Globe Body)						
Project Name	Revisions				SHEET	xx of xx
	NO.	BY	DATE	DESCRIPTION	SPEC. NO.	REVISION
	1				230901	*
	2				CONTRACT	DATE

		3				X	mm/dd/yy		
		4				PROJECT NUMBER			
		5				XXXX.XX			
		6				BY	CHECKED	APPROVED	
		7				XYZ	XYZ	XYZ	
GENERAL	Tag Number		*						
	Service Description		*						
	P&ID Sheet Number		*						
	Line No. or Vessel No.		*						
	Line Size / Mat'l / Sch.		*						
	Electrical Class	Power Supply	*			*			
PROCESS DATA	Fluid	Fluid State	WATER			LIQUID			
	Operating Condition		Units	Minimum	Normal	Maximum	Other		
	Flow Rate		GPM	*	*	*	*		
	Inlet Pressure		PSIG	*	*	*	*		
	Outlet Pressure		PSIG	*	*	*	*		
	Temperature		DEG F	*	*	*	*		
	Level		FEET	*	*	*	*		
	Mol. Wt.								
	Sp. Wt		Sp. Grav						
	Viscosity		Sp Heat						
BODY	Style	Size	GLOBE				xx"		
	End Connection	Rating	xx" RF FLANGED				ANSI CLASS 150		
	Port Size	Travel	*				*		
	Valve Cv	Valve C1/Km	*				**		
	Body Matl.	Bonnet	ASTM A216 WCC				ASTM A216 WCC		
	Characteristic	Trim Number	EQUAL PERCENTAGE				**		
	Cage Matl.	Retainer Matl.	*				*		
	Seat Matl.	Seat Ring Matl.	316 STAINLESS STEEL				316 STAINLESS STEEL		
	Plug Matl.	Stem Matl.	316 STAINLESS STEEL				316 STAINLESS STEEL		
	Flow Action		DOWN						
	Gaskets		PTFE						
	Stem Guide		**						
	Packing		PTFE						
	Required Seat Tightness		ANSI CLASS IV						
	Max. Allowable Sound Level (dBA)		<75 dBA						
	ACTUATOR	Type		PNEUMATIC					
		Size	Bench Set	*				*	
		Push-Down To	Fail Position	CLOSE*				CLOSE*	
Close At		Open At	6 PSIG*				30 PSIG*		
Handwheel		NONE*							
POSITIONER	Type		Electronic						

	Communications Protocol		*
	Input Signal	Output Signal	4-20 mA
	Air Supply		80 PSIG NOMINAL *
TRANSDUCER	Type		*
	Input Signal		*
	Output Signal		*
OPTIONS	Air Set w/ Gauges		YES*
	Solenoids		*
	Position Switches		*
SELECTION BASED ON	Manufacturer		Fisher, Valtek, Dezurik-Copes, Leslie
	Valve Model Number		*
	Actuator Model No.		*
	Positioner Model No.		*
	Filter Regulator		YES
NOTES	<i>* Engineer shall fill in to suit application.</i> <i>** Vendor to confirm based on process data provided.</i>		

END OF SECTION 230901