SECTION 25 30 00
BUILDING AUTOMATION AND INSTRUMENTATION

1. GENERAL
	1. Section Includes
		1. System Architecture
		2. Controllers
		3. Sensors and Input Devices
		4. Output Devices
		5. Power Supplies and Transformers
		6. Actuators
		7. Control Dampers
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		9. Lighting Control Relays
		10. Pneumatic Temperature Control System
		11. Control Air Piping
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	2. Related Sections
		1. 23 05 00.20 Basic HVAC Requirements
		2. 23 05 03 Through Penetration Firestopping
		3. 23 05 13 Motors
		4. 23 05 29 HVAC Supports and Anchors
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		6. 23 09 13 Instrumentation
		7. 23 21 23 HVAC Pumps
		8. 23 31 00 Ductwork
		9. 23 33 00 Ductwork Accessories
		10. 23 34 16 Centrifugal Fans
		11. 23 36 00 Air Terminal Units
		12. 23 57 00 Heat Exchangers
		13. 23 72 00 Energy Recovery Devices
		14. 23 73 13 Indoor Modular Air Handling Units
		15. 23 73 23 Custom Air Handling Units
		16. 23 82 00 Terminal Heat Transfer Units
		17. 26 05 00 Basic Electrical Requirements
		18. 33 00 00 Utilities Descriptive Narrative and Utilities Specs
	3. References
		1. ASHRAE 85 Automatic Control Terminology for Heating, Ventilating, Air Conditioning
		2. ASME MC85.1 Terminology for Automatic Control
		3. NEMA EMC1 Energy Management Systems Definition
		4. NFPA 70 National Electric Code
		5. NFPA 90A Air Condition systems
		6. NFPA 101 Life Safety Code
		7. ANSI A117.1 Accessible and Usable Buildings and Facilities
	4. System Descriptions
		1. The Owner has a campus-wide web-based Johnson Controls Building Automation System. Provide a fully integrated Building Automation System (BAS) incorporating the components herein specified and indicated on the drawings. System shall include electric, electronic and pneumatic components to provide a complete functioning Direct Digital Control System.
		2. All materials and equipment shall be standard components regularly manufactured for this and/or other systems. All components shall be thoroughly tested and proven in actual use.
		3. The BAS system shall provide automatic decision-making and control for building heating, ventilating, and air conditioning (HVAC) along with other functions. The Owner has a contract with Johnson Controls, Incorporated, for controls components and instrumentation installation sub-contractor, for materials and installation of all Johnson Controls equipment. As part of this contract, Johnson Controls has agreed to provide controls and instrumentation systems to Contractors on Iowa State University Capital projects. For assistance contact:

Account Manager

Johnson Controls, Inc.

11318 Aurora Ave

Des Moines, IA 50322

(515)-252-0100 (office) (515)-252-0001

* + 1. Contract Allowance for sale of controls and instrumentation to Contractor: Contractor to include an allowance in the Contract Sum for purchase and installation of controls and instrumentation specified in this Section including delivery to job site, unloading, handling, and all required taxes. Include all costs associated with coordination, preparation, mark-up, overhead, and profit for Contractor or any Subcontractors other than Johnson Controls in Contractor’s base bid sum and not this allowance. Johnson Controls has agreed to provide pricing for controls and instrumentation in accordance with the Iowa State University discount schedule. See Specifications Section 01 21 00 for Schedule of Allowances and allowance amounts
	1. Scope
		1. Provide, assemble, mount, and wire all devices and system components.
		2. Provide and supervise Control System sub-contractor performing installation of control system components.
		3. Actively participate in the Coordination effort with other Trades and Contractors.
		4. Assist the Commissioning Agent and Balancing Sub-Contractor.
		5. Facilitate and perform the complete checkout of the entire system, verifying proper operation in accordance with design specifications.
		6. Provide the following programming services:
			1. Define BAS software programming to accomplish sequence of operation per the project specification and drawings. Load the software program into the electronic devices.
			2. Provide software program and all program documentation.
			3. Build User View’s in a manner consistent with the Owner’s preferred folder layout and point naming convention.
			4. Incorporate final redline changes from contractor record drawings.
			5. Provide electronic graphics for the building automation system. Graphics should be provided for all Air Handling Units and Heat Exchangers (both chilled and hot water).
			6. Update system global files.
		7. Owner Training
		8. Provide training to Owner’s maintenance and engineering staff at the close of the project in two separate sessions:
			1. On Site Training: Show the location of all Metasys panels, controllers, and hardware components to the Owner’s staff. This should include safety devices such as static pressure and end switches and the location of fire/smoke dampers.
			2. Metasys Training: Explain the folder layout of the User View’s related to this project within the Metasys system; where to find key control points; and how to effectively start-up and shut-down the system. Explain all color graphics when applicable.
	2. Components Pricing
		1. The Controls Contractor, as a subcontractor, shall provide pricing to the next higher-level hierarchy of the subcontractor/contractor relationship as a lump sum price for all components included in this section and as indicated on the project drawings.
	3. Coordination
		1. The following incidental work shall be furnished by the designated contractor under the supervision of the Controls Contractor. The Controls Contractor shall provide all required information, materials, direction, and training to the designated contractor as required to provide a complete working system.
		2. The General Contractor shall:
			1. Provide access doors or other approved means of access in concealed ceilings and walls for service of control equipment.
			2. Provide all necessary cutting, patching and painting.
		3. The Mechanical Contractor shall:
			1. Install control valves and sensor wells that are provided by the controls contractor.
			2. Provide necessary valved pressure taps, water, drain and overflow connections and piping.
			3. Install automatic dampers, required interconnection linkages and extend damper shafts as necessary for mounting of actuators.
			4. Provide access doors or other approved means of access in ductwork and equipment for installation and service of control equipment.
		4. The Electrical Contractor shall:
			1. Provide auxiliary contacts, buttons and switches on all starters as required
			2. Provide power wiring (120V or greater) to control panels, motor starters, variable frequency drives, motors, electric actuators, electric devices, and smoke detectors.
	4. Submittals for Review
		1. Division 01 33 00 Submittal Procedures.
		2. Control System Shop Drawings:
			1. Bid Issue Control Shop Drawings are generated through a collaborative effort between the Owner, Design Professional, and Johnson Controls, Inc.
			2. Bid Issue Control Shop Drawings are the basis for the pricing and scope of the Control System Allowance amount.
		3. Shop Drawings and Equipment Product Data:
			1. Provide Valve Schedules indicating size, type, design flow, valve capacity, pressure drop and CV value, identification and part number.
			2. Provide Dampers Schedule indicating dimension and descriptions of blank-offs, installation location, damper features, identification and part number.
			3. Provide Shop Drawings and Product Data for vendor supplied equipment that will be installed by mechanical contractor (e.g. laboratory air valves).
			4. Shop Drawings and Product Data are not required for BAS panels or specific parts included in the bill of materials in panel drawings.
			5. Bid Issue Control System Shop Drawings shall be posted on the Owner’s project website by the Owner under the Bid\Reference Materials tab.
	5. Submittals at Closeout
		1. Division 01 77 00 Closeout Procedures - Contract Closeout; Procedures for maintenance documents and submittals.
		2. Project Record Documents: Maintain documents and submit at Contract Closeout.
		3. Operation and Maintenance Data Include:
			1. Red-mark "Record" control system drawings and then turn them over to the Owner’s Representative.
	6. Warranty
		1. The scope of work included in this section shall be guaranteed to be free from original defects on material for a period of three (3) years and workmanship for the period of one (1) year.
1. PRODUCTS
	1. Manufacturers
		1. Johnson Controls Inc. unless otherwise indicated.
	2. System Architecture
		1. The BAS shall be provided with a Master Control Panel and shall function as the overall system coordinator and shall be capable of integrating multiple building functions including HVAC equipment supervision and control, building equipment monitoring, alarm management, energy management, information management, historical data, collection and archiving. The BAS shall consist of individual DDC Control Panels, Application Specific Controllers, and Local Display Devices.
		2. The system architecture shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Control Panel shall operate independently from all other control components and will maintain control strategies when other components in system fail.
		3. Communication networks between control panels shall be made without the need for a central processing controller.
	3. Controllers
		1. NETWORK CONTROL UNIT
			1. SNE
				1. Shall be housed in a pre-built 20” x 24” x 9” enclosure complete with power supply, circuit breaker, convenience outlet, control transformer and 5 port Ethernet switch.
				2. Network Engine(s) shall be served by a Panel UPS Back-up unit in a 14” x 16” x 6” enclosure.
		2. Application Specific Controller
			1. CGM Controller
			2. FAC Controller
			3. VMA Series Controller
			4. IOM Controller
		3. Local Control Panels
			1. All control panels shall be factory constructed, incorporating the FMS manufacturers standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance. Control panels shall be fully enclosed, with sub-panel, hinged door, and slotted flush latch.
			2. In general, the control panels shall consist of the DDC controller (and I/O devices - such as relays, transducers, and so forth - that are not required to be located external to the control panel due to function.
			3. All other wiring in the panel, internal and external, shall be made to additional line or low voltage color-coded and labeled terminal strips. Low and line voltage wiring shall be segregated. All terminal strips and wiring shall be UL listed 300-volt service and provide adequate clearance for field wiring.
			4. All wiring for every control panel shall follow a common color-coded format. All terminal strip color coding and numbering shall follow a common format. All wiring shall be neatly installed in plastic trays or tie-wrapped.
			5. A convenience 120 VAC duplex receptacle, fused on/off power switch, and required transformers shall be provided in each enclosure.
	4. Sensors and Input Devices
		1. Temperature Sensors
			1. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
			2. The temperature sensor shall be of the resistance type and shall be either two-wire 1,000-ohm nickel RTD, or two-wire 1000 ohm platinum RTD.
			3. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:

| Point Type | Accuracy |
| --- | --- |
| Chilled Water | + .5°F. |
| Room Temp | + .5°F. |
| Duct Temperature (Averaging) | + .5°F. |
| All Others | + .75°F. |

* + 1. Room Temperature Sensors
			1. Room sensors shall be constructed for either surface or wallbox mounting.
			2. Room sensors shall have the following options when specified:
				1. 1,000-ohm thin film nickel sensor.
				2. Unless noted otherwise, sensor shall be connected via modular jack and communicate via the controller’s SA buss.
				3. Flat plate sensors shall be installed where tampering or damage is a concern (e.g. vestibules, restrooms, etc.).
				4. Acceptable manufacturers: Johnson Controls.
		2. Humidity Sensors – Low to Moderate Humidity Applications
			1. Low to Moderate Humidity Applications are locations where the relative humidity being measured does not exceed 90% for a continuous period of 24 hours.
			2. The sensor, duct or wall-mounted, shall be a solid-state type, relative humidity sensor of the thin film capacitance design. The sensor element shall resist service contamination.
			3. Sensor shall have both temperature and humidity output channels.
			4. Shall not come with any buttons or display.
			5. The humidity transmitter shall be equipped a 0-100% linear proportional 0-10 VDC output and shall be powered by 24 VAC.
			6. The humidity transmitter shall meet the following overall accuracy:
				1. 10 to 30 deg C

30-70% RH - ±3 %RH.

0-30% RH, 70-100% - ±5 %RH.

* + - 1. -5 to +10 deg C, 30 to 55 deg C

0-100 %RH - ±7%RH.

* + - 1. Humidity sensing element shall be field replaceable are require no re-calibration after replacement.
			2. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.
				1. Duct type sensors shall be provided with stainless steel sintered filter.
			3. Acceptable Manufacturers: Vaisala INTERCAP Series.
		1. Humidity Sensors – High Humidity Applications
			1. High Humidity Applications are locations where the relative humidity being measured can exceed 90% for a continuous period of 24 hours.
			2. The sensor, duct or wall-mounted, shall be a solid-state type, relative humidity sensor of the thin film capacitance design. The sensor element shall resist service contamination.
			3. Sensor shall have both temperature and humidity output channels.
			4. The humidity transmitter shall be equipped a 0-100% linear proportional 0-10 VDC output and shall be powered by 24 VAC.
			5. The humidity transmitter shall meet the following overall accuracy:
				1. 0 to 40 deg C

0-90% RH - ±1.7 %RH.

90-100% RH - ±2.5 %RH.

* + - * 1. -40 to 0 deg C, 40 to 80 deg C

0-90% RH - ±3.0 %RH.

90-100% RH - ±4.0 %RH.

* + - 1. For duct applications, shall come with duct installation kit.
			2. Shall come with stainless steel sintered filter.
			3. Acceptable Manufacturers: Vaisala HUMICAP Series.
		1. Thermowells
			1. When thermowells are required, the sensor and well shall be supplied as a complete assembly, including well head and Greenfield fitting.
			2. Thermowells shall be pressure rated and constructed in accordance with the system working pressure.
			3. Thermowells and sensors shall be mounted in a threadolet or 1/2” NFT saddle and allow easy access to the sensor for repair or replacement.
			4. Thermowells shall be constructed of brass.
			5. Provide bushings as necessary to accommodate thread size differences between thermowell and threadolet.
		2. Outside Air Sensors
			1. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
			2. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
			3. Temperature transmitters shall be of NEMA 3R (IP54) or NEMA 4 (IP65) construction and rated for ambient temperatures.
			4. The outdoor sensor can be easily mounted on a roof, pole or side of a building utilizing its already assembled mounting bracket.
			5. Outside Relative Humidity sensors 0-100% full range of accurate measurement. Operating temperature -4 to 140F (-20 to 60C).
			6. Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R (IP54) or NEMA 4 (IP65) enclosure with sealtite fittings.
			7. Outside temperature sensors operating temperature range is -40 to 140F, +/- .55F (+/- .3C).
			8. Acceptable Manufacturers: Vaisala HUMICAP Series, Johnson Controls.
		3. Duct Mount Sensors
			1. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
			2. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
			3. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
		4. Averaging Sensors
			1. For ductwork greater in any dimension than 48 inches and/or where air temperature stratification may exist, an averaging sensor with multiple sensing points shall be used.
			2. For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.
			3. Capillary supports at the sides of the duct shall be provided to support the sensing string.
			4. Acceptable manufacturers: Johnson Controls.
		5. Pressure Transmitters
			1. General Air and Water Pressure Transmitter Requirements:
				1. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.
				2. Transmitters shall be powered by 24 VAC.
				3. Pressure transmitters shall transmit a 0 to 10 VDC output signal.
				4. Pressure transmitters shall have field selectable pressure ranges, along with zero and span adjustment.
				5. A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.
				6. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.
				7. Acceptable manufactures: Veris, Setra.
			2. The following table shows the required range, accuracy, display and pressure requirements for each application.



* + 1. Fan Inlet Air Flow Measuring Stations
			1. Measuring station shall use thermal dispersion technology to determine the air velocity. Shall be factory calibrated at 16 points to NIST-traceable standards.
			2. Thermistors shall be hermetically sealed, bead-in-glass type sensors.
			3. Calibrated Range: 0 to 10,000 fpm.
			4. Operating Temperature: -10 to 160 deg F.
			5. Power Requirements: 24 VAC.
			6. Accuracy: Airflow: ±2% of reading, Temperature: ± 0.15°F.
			7. Transmitter output shall be 0-10 VDC.
			8. Acceptable manufactures: Ebtron Gold Series.
		2. Duct Air Flow Measuring Stations
			1. Measuring station shall use thermal dispersion technology to determine the air velocity. Shall be factory calibrated at 16 points to NIST-traceable standards.
			2. Sensor density shall be selected in accordance with manufacturer recommendations.
			3. Calibrated Range: 0 to 5,00 0 fpm.
			4. Operating Temperature: -20 to 160 deg F.
			5. Power Requirements: 24 VAC.
			6. Accuracy: Airflow: ±2% of reading, Temperature: ± 0.15°F.
			7. Transmitter output shall be 0-10 VDC.
			8. Acceptable manufactures: Ebtron Gold Series.
		3. Duct Static Pressure Probe
			1. Duct static probes shall be provided where required to monitor duct static pressure. The probe shall contain multiple static pressure sensors located along exterior surface of the cylindrical probe.
			2. Acceptable manufacturers: Dwyer, Johnson Controls, Air Monitor.
		4. Shielded Static Air Probe
			1. A shielded static pressure probe shall be provided at all four faces of the building, preferably on the penthouse, as the outdoor air reference pressure The four pressure sensing points shall be piped pneumatically to a PVC accumulator tank located in an accessible location.
			2. The indoor reference sensing location shall be installed in an accessible location and with its location noted on the as-built drawings.
			3. Acceptable manufacturers: Dwyer.
		5. Status and Safety Switches
			1. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the FMS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.
			2. Current Sensing Switches
				1. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.
				2. Shall be split-core.
				3. The CT shall be a separate device from the start relay.
				4. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.
				5. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.
				6. Acceptable manufacturers: Johnson Controls, Veris.
		6. Air Filter or Air Flow Status Switches
			1. Differential pressure switches used to monitor air filter or air flow status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.
			2. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.
			3. Provide appropriate scale range and differential adjustment for intended service.
			4. Acceptable manufacturers: Johnson Controls.
		7. Damper Position Switches
			1. Shall use a roller ball and mechanical switch to provide open/closed damper position status.
			2. Shall fasten to damper shaft.
			3. Shall not contain mercury.
			4. Shall feature SPDT switch type, rated at 5A @ 120/250 VAC.
			5. Switch shall make at 20 degrees above horizontal and break at 15 degrees below horizontal.
			6. Acceptable manufacturers: Kele, MDI TS-475 Series.
		8. Wet/Dry Switch
			1. Switch is used to indicate that cooling coil has been drained for winter operation.
			2. Selector switch shall be provided in NEMA 12/13 pushbutton enclosure.
			3. 2 position switch shall be provided with one normally open contact.
			4. Contact rating: 10A @ 600 VAC/VDC; 3 VAC/VDC minimum.
			5. Mechanical life shall be 500,000 minimum operations.
			6. Acceptable manufacturers: Kele, IDEC ASW Series.
		9. Air Pressure Safety Switches
			1. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120 VAC.
			2. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.
			3. Acceptable manufacturers: Johnson Controls, Cleveland Controls.
		10. Low Temperature Limit Switches
			1. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.
			2. The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.
			3. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.
			4. Acceptable manufacturers: Johnson Controls.
		11. Carbon Dioxide Sensor:
			1. Sensor shall be solid state with a range of 0 to 2000 parts per million (ppm) CO2.
			2. Sensor shall be powered by 24VAC and provide a 0-10 VDC output.
			3. Provide enclosure suitable for installation location.
			4. Acceptable manufacturers: Johnson Controls, Vaisala, Veris.
		12. Water Detector
			1. Used in basement levels to detect water on the floor.
			2. Shall be powered by 24 VAC.
			3. Shall be equipped with field selectable normally open and normally closed contacts.
			4. Shall be height adjustable.
			5. Shall have green LED power indicator light.
			6. Shall have red LED water detection light.
			7. SPDT alarm contact shall be rated for 1A @ 24 VAC/VDC.
			8. Acceptable manufacturer: Kele.
	1. Output Devices
		1. Control Relays
			1. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
			2. Mounting bases shall be snap-mount.
			3. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
			4. Contacts shall be rated for 10 amps at 120VAC.
			5. Relays shall have an integral indicator light and check button.
			6. Acceptable Manufacturers: Johnson Controls, RIB.
		2. Electronic/Pneumatic Transducers
			1. Output: 0-15 PSIG.
			2. Input: 0-10 VDC.
			3. Install pressure gauge on outlet of pressure transducer.
			4. Acceptable Manufacturers: Johnson Controls EP-8000.
	2. Power Supplies and Transformers
		1. Transformers
			1. Sized to provide volts and amps as required for connected load.
			2. Input voltage shall be as required for the specific application.
			3. Shall not exceed 500VA, prefer to have 500VA enclosure with five (5) 100VA circuits.
			4. Acceptable Manufacturers: Functional Devices PSH500 Series.
	3. Actuators
		1. General Requirements
			1. Damper and valve actuators shall be electronic and/or pneumatic, as specified in the System Description section.
			2. The manufacturer shall be ISO 9001 certified.
		2. Electronic Damper Actuators
			1. Spring Return Actuators:
				1. Manufactured, brand labeled or distributed by Johnson Controls, Inc. or approved equivalent.
				2. Regulatory Agency Listing: cULus ,CSA C22.2 No. 24-93, and CE marked.
				3. Direct-Coupled Design: Requires no crankarm or linkage for mounting to a shaft.
				4. Coupling: toothed V-bolt clamp and nuts with toothed cradle.
				5. Reversible Mounting: Provides either clockwise or counterclockwise operation.
				6. Power Failure Operation: Mechanical spring return system drives load to the home position. Other forms of internal energy storage for power failure operation are not acceptable.
				7. Motor Technology:

Modulating Types: Microprocessor-controlled Brushless DC motor.

On/Off Types: DC brush motor.

* + - * 1. Overload Protection: Electronic stall detection protects from overload at all angles of rotation without the use of end switches.
				2. Enclosure Ratings:

NEMA type 2 / IP54 mounted in any orientation.

* + - * 1. Double-Insulated construction: Eliminate the need for electrical ground wires.
				2. Wiring: Integral cables with colored and numbered conductors.
				3. Sized for torque required to seal damper at load conditions.
				4. Parallel Operation: Actuators shall be available that are capable of being mechanically or electrically paralleled.
				5. Proportional actuators shall be user configurable without the use of external computer software or programming tools. Calibration, input signal range selection, and control logic reversal shall be selectable with an external mode selection switch.
				6. Operating Temperature Range:

70 lb·in. Torque and Below: -40°F to 140°F.

71 lb·in. Torque and above: -40°F to 131°F.

* + - * 1. Power Requirements:

Modulating Types:

27 lb·in. Torque and Below: 5VA maximum.

70 lb·in. to 19 lb·in. Torque: 8VA maximum.

89 lb·in. to 71 lb·in. Torque: 10VA maximum.

90 lb·in. to 177 lb·in. Torque: 16VA maximum.

2-Position Types:

27 lb·in. Torque and Below: 5VA maximum.

70 lb·in. to 19 lb·in. Torque: 7VA maximum.

71 lb·in. to 177 lb·in. Torque: 25VA maximum.

* + - 1. Non-Spring Return Actuators:
				1. Manufactured, brand labeled or distributed by Johnson Controls, Inc. or approved equivalent.
				2. Regulatory Agency: UL Listed, CSA Certified, and CE marked.
				3. Direct-Coupled Design: Requires no crankarm or linkage for mounting to a shaft.
			2. Coupling:
				1. Above 80 lb·in.: toothed V-bolt clamp and nuts with toothed cradled.
				2. 80 lb·in. and below: single cup-point set screw and toothed cradle.
			3. Overload Protection: Electronic stall detection or magnetic slip clutch protects from overload at all angles of rotation without the use of end switches.
			4. Minimum Enclosure Ratings:
				1. Types with covered wiring terminals: NEMA type 2 / IP42 mounted in any orientation.
				2. Types without covered wiring terminals: NEMA type 1 / IP30 or IP40.
				3. Types with integrated cables: NEMA 2 / IP42 mounted in any orientation.
			5. Sized for torque required to seal damper at load conditions
			6. Parallel Operation: Actuators shall be available that are capable of being mechanically or electrically paralleled.
			7. Proportional actuators shall be user configurable without the use of external computer software or programming tools.
			8. Operating Temperature Range: -4°F to 122°F except for VAV and similar indoor applications in which case 32°F to 122°F is acceptable.
			9. Power Requirements: 24 V with models available for both 24 VAC and 24 VDC operation, maximum 0.
				1. Above 80 lb.·in.: 7.5 VA at 24 VAC.
				2. 80 lb.·in.and below: 3.5 VA at 24VAC.
			10. The manufacturer shall provide 5-year limited warranty from the date of sale covering defects in material or workmanship.
		1. Pneumatic Damper Actuators
			1. Rolling-diaphragm, piston type with adjustable stops and spring return, sized to operate with sufficient reserve power to provide smooth modulating action or 2-position action. Where actuators operate in sequence, provide pilot positioners.
				1. Pilot positioners starting point shall be adjustable from 2 to 12 PSI and an operating span adjustable from 5 to 13 PSI.
				2. Inlet vanes operators shall be high pressure with pilot positioners.
			2. Acceptable manufacturers: Johnson Controls.
		2. Electronic Valve Actuators
			1. Electronic valve actuators shall be manufactured by the valve manufacturer.
			2. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
			3. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized based on valve manufacturer’s recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.
			4. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 0-10 VDC and the actuator shall provide a clamp position feedback signal of 0-10 VDC. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
			5. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.
			6. Acceptable manufacturers: Johnson Controls, Belimo.
		3. Pneumatic Valve Actuators
			1. Rolling-diaphragm, spring-loaded, piston type with spring range as required. Select operator for full shutoff at maximum pump differential pressure.
			2. Acceptable manufacturers: Johnson Controls or approved equal.
	1. Control Dampers – Standard Construction
		1. The BMS Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BMS Contractor or as specifically indicated on the Drawings.
		2. All dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.
		3. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.
		4. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60”. Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48”x48” size shall not leak in excess of 8.0 cfm per square foot when closed against 4” w.g. static pressure when tested in accordance with AMCA Std. 500.
		5. Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5” w.g., but no more than 4000 FPM or 6” w.g.
			1. Acceptable manufacturers are Johnson Controls, Ruskin, Vent Products, and TAMCO.
		6. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below.
			1. Acceptable manufacturers are Johnson Controls, Ruskin, Vent Products, and TAMCO.
		7. Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.
	2. Thermally Insulated Control Dampers
		1. Shall be licensed to bear the AMCA Certified Rating Seal.
		2. Test leakage and pressure drop per AMCA 500.
		3. [Frame](file:///%5C%5Csvkjwwfs2%5Ch%5Cmech%5Ccommittee%5Ccontrols%5CCut-Sheets%5CControl%20Dampers%5CThermally%20Insulated%5CTAMCO%209000%20SC.pdf): Extruded aluminum, minimum 4” deep, 0.080” minimum thickness. Frame shall be insulated with Styrofoam on three sides if installed in duct and four sides if flanged to duct.
		4. Blades: Minimum 12 gauge extruded aluminum airfoil design, minimum 6” wide, internally insulated with expanded polyurethane foam and thermally broken, with overlapping blades and blade seals (overlapping blade seals only is unacceptable).
		5. Shaft: Non-cylindrical, solid aluminum shaft with opening in blade to match profile of shaft. Shaft shall be securely fastened to the blade and of sufficient length to mount direct-coupled actuator. Damper manufacturer shall provide drive pin extensions and outboard bearing support brackets as required.
		6. Bearings: Acetal (Delrin/Celcon) inner bearing fixed to an aluminum shaft, rotating within a polycarbonate outer bearing inserted in the frame. Provide thrust bearings for vertical damper applications.
		7. Side Seals: Stainless steel compression type or extruded silicone gasket secured in an integral slot within the frame.
		8. Linkage: Shall be concealed in the frame, constructed of aluminum or corrosion-resistant zinc plated steel, and securely fastened to shaft. Blades linked for opposed operation, unless noted otherwise on the drawings. Blades shall close evenly. Use one direct-coupled actuator per damper section. Jack-shafting is not acceptable.
		9. Size Limits: 48" maximum horizontal blade length, 24 square foot maximum area per damper. Total cross-sectional area of dampers in ducts shall be at least as large as the duct without the use of blank-off sections.
		10. Maximum Leakage: 15 cfm at 1” w.c. pressure differential for a 24”x24” damper.
		11. Maximum Pressure Drop: 0.21” for 8,000 cfm through a 24”x24” damper (2000 fpm).
	3. Control Valves
		1. Ball Valves, 1/2 through 2 in.:
			1. Ball Valves shall have forged brass bodies.
			2. Valves shall have available either Chrome Plated Brass Balls or 300 Series Stainless Steel Balls in all sizes.
			3. Valves shall have available either Nickel Plated Brass Stems or 300 Series Stainless Steel Stems with a blow-out proof stem design in all sizes.
			4. Valves shall have Graphite reinforced Polytetrafluoroethylene (PTFE) seats with Ethylene Propylene Diene Monomer (EPDM) O-ring backing.
			5. Stem seals shall be double EPDM O-rings.
			6. Flow Characterization Disk shall be manufactured from Amodel AS-1145HS Polyphthalamide Resin and rated for 50 psid maximum differential pressure and shall be inserted against the casting of the valve.
			7. All ball valves with internal pipe thread end connections shall be rated to 580 psi maximum static pressure at 203°F (95°C) fluid temperature.
			8. All ball valves with sweat end connections or press end connection shall be rated to 300 psig maximum static pressure at 203°F (95°C) fluid temperature.
			9. All valves shall be rated for service with hot water, chilled water and 50% glycol solutions.
			10. Ball Valves with stainless steel balls and stems shall be rated for use with 15 psig saturated steam.
			11. Flow Characteristics shall be equal percentage on the control port. Bypass port on three-way valves shall have linear flow characteristics.
			12. Valves shall have a maximum leakage specification of 0.01% of maximum flow for the control port, ANSI/FCI 70-2, Class 4 and 1% of maximum flow, bypass port.
			13. Valves shall be maintenance free.
			14. Valves shall be provided with a 5-year warranty.
			15. Valves shall be rated for 200 psid closeoff pressure.
			16. Valve actuators shall be UL-recognized or CSA-certified.
			17. Valves shall be Johnson Controls VG1000 Series ball valves or approved equal.
		2. Ball Valves, 2-1/2 through 4 in. Flanged:
			1. Ball Valves shall have forged brass bodies with ASME Class 150 ductile iron flanges.
			2. Valves shall have 300 Series Stainless Steel Balls.
			3. Valves shall have 300 Series Stainless Steel Stems with a blow-out proof stem design.
			4. Valves shall have Graphite reinforced Polytetrafluoroethylene (PTFE) seats with Ethylene Propylene Diene Monomer (EPDM) O-ring backing.
			5. Stem seals shall be double EPDM O-rings.
			6. Flow Characterization Disk shall be manufactured from Amodel AS-1145HS Polyphthalamide Resin and rated for 50 psid maximum differential pressure.
			7. Flow Characteristics shall be equal percentage on the control port. Bypass port on three-way valves shall have linear flow characteristics.
			8. Valves shall have a maximum leakage specification of 0.01% of maximum flow for the control port, ANSI/FCI 70-2, Class 4 and 1% of maximum flow, bypass port.
			9. All valves shall be rated for service with hot water, chilled water, 50% glycol solutions and rated for use with 25 psig saturated steam.
			10. Two-Way Valves shall be rated for 100 psid closeoff pressure and Three-Way Valves shall be rated for 50 psid closeoff pressure.
			11. Valves shall be maintenance free.
			12. Valves shall be provided with a 5-year warranty.
			13. Valve actuators shall be UL-recognized or CSA-certified.
			14. Valves shall be Johnson Controls VG1000 Series ball valves or approved equal.
		3. Butterfly Valves, 2 through 20 in. resilient seat ASME Class 125/150 Flanged:
			1. Butterfly Valves shall have cast iron bodies meetings ASTM A126 Class B requirements and meet ASME class 125/150 flange requirements and shall be fully lugged.
			2. Butterfly Valves seat shall be Ethylene Propylene Diene Monomer (EPDM).
			3. Butterfly Valve disk shall be Ductile Iron with Nylon 11 coating.
			4. Butterfly Valve stems shall be Stainless Steel.
			5. Flow Characteristics shall be equal percentage up to 70° of disk rotation.
			6. All valves shall be rated for service with hot water, chilled water and 50% glycol solutions.
			7. Valves shall be maintenance free.
			8. Valve shall be provided with a 3-year warranty.
			9. Valve electric actuators shall be UL-recognized or CSA-certified.
			10. Valves shall be Johnson Controls VF Series butterfly valves or approved equal.
		4. Butterfly Valves, High Performance 2-1/2 through 16 in.
			1. Butterfly Valves shall have bodies manufactured from Carbon Steel, ASTM A216 GR WCB/A516 GR 70 and shall be fully lugged per ASME Class 150 or ASME Class 300.
			2. Butterfly Valves seat assembly shall be RPTFE (reinforced polytetrafluoroethylene) and the seat retainer shall be Carbon Steel, ASTM A516 GR 70.
			3. Butterfly Valve disk shall be Stainless Steel, ASTM A 351 GR CF8M.
			4. Butterfly Valve stems shall be 17-4 PH Stainless Steel, ASTM A564-Type 630.
			5. Butterfly Valve Stem Seals shall be One Carbon Fiber Ring and Three TFE Rings.
			6. Flow Characteristics shall be equal percentage up to 70° of disk rotation.
			7. All valves shall be rated for service with hot water, chilled water, 50% glycol solutions and 50 psig saturated steam in modulating service or 150 psig saturated steam in two position service.
			8. Butterfly Valves shall meet the performance requirements of ASME Class 150 or Class 300.
			9. Valves shall be maintenance free.
			10. Valves shall be provided with a 3-year warranty.
			11. Valve electric actuators shall be UL-recognized or CSA-certified.
			12. Valves shall be Johnson Controls VF Series butterfly valves or approved equal.
		5. Globe Valves, Brass, 1/2 through 2 in.
			1. Valves shall have bodies manufactured from a RoHS compliant brass.
			2. Valves shall meet the pressure and temperature requirements of ANSI B16.15, Class 250.
			3. Valve stems shall be a 300 Series Stainless Steel.
			4. Valves with brass plug and seat shall have stem seals with Self-Adjusting Ethylene Propylene Rubber (EPR) Ring Pack U-Cups.
			5. Valves with Stainless Steel plug and seat shall valve stem seals with Spring Loaded Polytetrafluoroethylene (PTFE) and Elastomer V-Rings.
			6. Valves with brass trim shall have a maximum leakage specification of 0.01% of maximum flow per ANSI/FCI 70-2, Class 4 and valves with stainless steel trim shall have a maximum leakage of 0.05% of maximum flow.
			7. Flow Characteristics shall be equal percentage for two-way valves and linear for three-way valves.
			8. Valves shall be serviceable without being removed from the pipe.
			9. Valves shall be provided with a 3-year warranty.
			10. Valve electric actuators shall be UL-recognized or CSA-certified.
			11. Valves shall be Johnson Controls VG7000 Series globe valves or approved equal.
		6. Globe Valves, Cast Iron, 2-1/2 through 6 in.
			1. Valves shall have bodies manufactured from cast iron.
			2. Valves shall meet the pressure and temperature requirements of ANSI B16.1, Class 125.
			3. Valve stems shall be a 316 Series Stainless Steel.
			4. Valves shall have stem seals with Ethylene Propylene Terpolymer (EPT) Ring Pack U-Cups.
			5. Valves shall have a maximum leakage specification of 0.1% of maximum flow per ANSI/FCI 70-2, Class 3.
			6. Flow Characteristics shall be equal modified linear.
			7. Valves shall be serviceable without being removed from the pipe.
			8. Valves shall be provided with a 3-year warranty.
			9. Valve electric actuators shall be UL-recognized or CSA-certified.
			10. Valves shall be Johnson Controls VG2000 Series globe valves or approved equal.
		7. Electric Zone Valves, 1/2 through 1-1/4 in.
			1. Valves shall have bodies manufactured from Forged Brass.
			2. Valves stems shall be brass (Hard Chrome Plated).
			3. Valve Actuator shall be UL, cUL listed or CSA certified.
			4. Valves shall be rated for service with hot water, chilled water and 50% glycol solutions.
			5. Two Position valves shall have models available rated for use with 15 psig saturated steam.
			6. Valve Actuator shall be replaceable without removing valve from the pipe.
			7. Modulating Valves flow characteristics shall be equal percentage.
			8. Valves shall be provided with a 2-year warranty.
			9. Valve actuators shall be UL-recognized or CSA-certified.
			10. Valves shall be Johnson Controls J Series electric zone valves or approved equal.
		8. Pressure Independent Valves, 1/2 through 2 in.
			1. Valves bodies shall be manufactured from forged brass and shall be nickel plated.
			2. Valves shall have a stem and ball manufactured from chrome plated brass.
			3. Valve seat shall be fiberglass reinforced with Teflon®.
			4. Characterizing disk shall be brass for 1/2 and 3/4 in. valves, and Tefzel® for sizes 1 through 2 in. valves.
			5. Valves shall pressure ratings of 600 psi for 1/2, 3/4 and 1 in. size valves, and pressure rating of 400 psi for 1-1/4, 1-1/2 and 2 in. size valves
			6. Closeoff Pressure rating shall be 200 psid.
			7. Valves shall have a maximum leakage specification of 0.01% of maximum flow per ANSI/FCI 70-2, Class 4 with a 50 psid differential pressure applied.
			8. Valves shall be maintenance free.
			9. Valves shall be provided with a 5-year warranty.
			10. Valve actuators shall be UL-recognized or CSA-certified.
			11. Valves shall be Johnson Controls P1000 Series pressure independent valves or approved equal.
	4. Pneumatic Temperature Control System
		1. Oil Removal and Pressure Reducing Stations
			1. Pressure reducing stations shall be provided at locations to ensure adequate quantity and pressure of instrument air to all controls furnished herein. A pressure gauge shall indicate the output of the PRV. For systems operating at 20 psig, a pop safety shall be furnished to protect instruments from excess air pressures.
			2. Shall feature a four-way bypass valve.
			3. Shall be equipped with a coalescing and activated carbon oil removing filter.
			4. Pneumatic tubing within station shall be copper.
			5. Acceptable manufactures: Johnson Controls A-4000.
	5. CONTROL AIR PIPING
		1. Instrument Air piping shall be specified copper or polyethylene tubing.
		2. Tubing fittings shall be brass or copper solder joint with compression fittings used at connections to equipment. Copper tubing shall be seamless Type M hard or soft temper.
		3. Polyethylene tubing shall be Fire Resistant with a density of .92 grams/cc, a melt index of .3 decigrams/min, and stress crack resistance of 2000 hrs. minimum per ASTM-D 1693.
	6. Low Voltage Cable
		1. Analog Input, Analog Output, Binary Input, Binary Output, 24 VAC and General Purpose Cabling.
			1. Cable shall consist of copper conductors not less No. 18 AWG-stranded.
			2. Shall be 2 or 3 conductor twisted cable with a drain wire.
			3. Cable shall have a 100% overall shield.
			4. Cable shall be a plenum-rated.
			5. Cable shall meet or exceed NEC voltage rating of 300V.
			6. Cable shall be NEC type CMP.
			7. Cable shall meet or exceed UL temperature rating of +60 degrees C.
			8. Cable shall be labeled at a minimum of every 18” with the DDC System manufacturer’s name and the type of signal carried within the cable, i.e. Analog Input, Analog Output, Binary Input, Binary Output, 24 VAC.
			9. Each of the cable types specified in Item A shall be of a different color coding for easy identification and troubleshooting. Required color coding:
				1. Analog Input Cable Yellow
				2. Analog Output Cable Tan
				3. Binary Input Cable Orange
				4. Binary Output Cable Violet
				5. 24 VAC Cable Gray
				6. General Purpose Cable Natural
		2. Primary and Secondary Communications Network Cabling.
			1. Cable shall be of type recommend by the DDC System Manufacturer.
			2. Primary cable shall be blue in color.
			3. Cable shall be shielded.
			4. Cable shall be a plenum-rated.
			5. Cable shall meet or exceed NEC voltage rating of 150V.
			6. Cable shall meet or exceed UL temperature rating of +60 degrees C.
			7. Cable shall be labeled at a minimum of every 18” with the DDC System manufacturer’s name, system name and the communications network name.
			8. Each of the cable types shall be of a different color-coding for easy identification and troubleshooting and shall be of a different color than the cable specified in Item A above.
		3. Acceptable Manufactures: Windy City Wire, Southwest Wire, Anixter, Cable Plus, Belden or approved equal.
1. EXECUTION
	1. General
		1. Completely install automatic temperature control system as specified.
		2. Coordinate installation of devices, wiring, and other items with other trades.
		3. Locate thermostat/sensors where they will not be affected by heat from other sources, such as direct rays of sun, pipes or ducts in wall, convectors, direct air currents from diffusers, light dimmers and similar items.
		4. Coordinate locations of space temperature sensors as indicated or approved by Owner’s representative and Architect. Verify mounting locations and alignment with Owner and Architect prior to final installation.
		5. Low temperature protection thermostat shall be located upstream of the cooling coil. The entire duct area shall be covered to detect low air temperature due to stratification.
		6. Current sensing relay trip levels shall be set to indicate the motor running under load vs. no load.
		7. Verify wiring terminations at all devices and correct as required. Provide typed identification label for each termination.
	2. Start-Up Services
		1. Verify proper location of each device and point-to-point BAS integrity, correct as needed.
		2. When installation is complete and automatic control system is placed in operation, adjust and calibrate all instruments and devices in system and ensure that system is operating in accord with specified sequences.
		3. Diagnose component and system problems. Communicate irregularities to the appropriate contractor for correction.
		4. Attend construction meetings as required to coordinate with other contractors and provide input during problem resolution.
	3. Sensors and Input Devices
		1. All Input devices shall be installed per the manufacturer’s recommendation.
		2. Building Differential Air Pressure Applications: Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind. The interior tip shall be inconspicuous and located within a central corridor shown on the drawings.
		3. Outside Air Humidity Sensors: Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with Sealtite fittings and stainless steel bushings.
		4. Outside Air Sensors: Outside air sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air temperatures accurately. Sensors exposed to solar radiation must be installed with solar shields. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate surrounding the sensor element.
		5. Space Temperature Sensors: Shall be mounted 42-50” above the finished floor.
		6. Low Temperature Limit Switches: Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.
		7. Duct Mount Sensors
			1. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
			2. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
			3. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
	4. Output Devices
		1. All output devices shall be installed per the manufacturer’s recommendation.
	5. Wiring
		1. Install wiring in accordance with National Electric Code; ANSI/NFPA 70.
		2. Install wiring (low and line voltage) in metal raceways or blue conduit unless inside control cabinet or unit enclosures. For concealed and accessible areas, plenum-rated wiring and cabling may be used.
		3. Class 2 wiring not installed in conduit shall be supported every 5’ from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements. Exposed wiring shall only be allowed in concealed accessible locations.
		4. Low voltage control wiring and 24VAC can be run in the same conduit. Power wiring 120VAC and greater must be in a separate conduit.
		5. Fastening shall be secured to walls or ceilings by means of appropriate screws, expansion screws anchors, toggle bolts, hollow wall screw anchors, nylon expansion anchors or expansion shields. All-purpose plastic anchors are not acceptable.
		6. Control panels shall be mounted on vibration-free walls or freestanding structural supports. Panels shall be located as indicated or approved by owner representative.
		7. Locate circuits, relays, transformers or other equipment that contains or must be connected to voltages exceeding 130 volts, in separate cabinets, which may be adjacent to control panels; permanently label "DANGER 277 VOLTS" or appropriate volts.
		8. All wiring in mechanical rooms shall be in blue conduit. Minimum control wiring conduit size 3/4”. Shall not exceed 40% fill ratio.
		9. No more than 2 feet of flexible conduit is allowed when making connections to control devices.
	6. Control Air Piping
		1. Install air piping system in accordance with manufacturer’s instructions.
		2. Run exposed copper tubing, conduits and tubing parallel to building lines, securely anchoring at regular intervals.
		3. Size air mains for proper application. Installation of air piping shall have a maximum pressure drop on mains and branches of 1.2 psig at maximum air consumption. Supply mains shall be tested for line loss over a 24hr period. Starting the testing procedure at 30 psig, the system shall not have a line loss greater than 5 psig.
		4. Tubing installed in mechanical rooms shall be hard copper tubing or polyethylene tubing protected by EMT conduit. Minimum conduit size is 3/4”. Install so that no polyethylene tubing is exposed except the last 18” to connect to the operators. Plastic end caps must be used when the polyethylene tubing leaves the conduit system.
		5. Tubing installed in exposed areas shall be hard copper tubing or polyethylene tubing protected by EMT conduit. Minimum conduit size is 3/4”.
		6. Tubing installed in concealed accessible areas shall be hard, soft annealed copper, or polyethylene tubing. Tubing installed in installed in a workmanlike manner, securely fastened to fixed members of the building structure at sufficient points to prevent excessive freedom of movement. Do not fasten tubing to ceiling suspension wires. Tie field fabricated bundles together with a sufficient number of nylon ties to present a neat, uniform appearance.
		7. Tubing installed in concealed inaccessible areas such as pour slabs, block walls, etc. shall be polyethylene tubing in EMT. The EMT shall not exceed 75% fill ratio.
	7. Incidental Control Wiring
		1. Examples of incidental control wiring include: boiler control systems, chimney automation system and variable frequency drives, chillers, etc. All incidental control wiring shall be provided by the temperature controls contractor.
	8. Identification Standards
		1. Field Devices. All field devices shall be identified by a typed (not handwritten) securely attached tag label.
		2. Controller Identification: All controllers shall be identified by typed (not handwritten) securely attached tag label.
		3. Panel Identification: All local control panels shall be identified by a typed (not handwritten) securely attached tag label securely fastened to the outside of the controller enclosure.
		4. Panel Devices: All panel devices shall be identified by a typed label securely fastened to the back plate of the local control panel.
		5. Raceway Identification. All the covers to junction and pull boxes of the control system raceways shall be painted blue or have identification labels stating “Control System Wiring” affixed to the covers. Labels shall be typed; handwritten labels will be rejected.
		6. Wire Identification. All low and line voltage control wiring shall be identified by a number, as referenced to the associated control diagram, at each end of the conductor or cable. Identification number shall be permanently secured to the conductor or cable and shall be typed.
	9. Monitoring of Devices Furnished by Owner or Other Contractors
		1. The temperature control contractor shall provide all labor and material necessary to monitor the status or provide start/stop command of the following equipment furnished by others (where applicable):
		2. Automated External Defibrillator (AED)
			1. Status
		3. Fire Alarm Panel
			1. Status
			2. Alarm
			3. Supervisory
		4. Air Filter Status (Dwyer - Photohelic®)
			1. Status
			2. Digital Output Alarm when Dirty
		5. Sump/Sewage Ejector Pumps
			1. Alarm Status
		6. Condensate Receivers
			1. Alarm Status
		7. Rainwater Sensing Devices
			1. Alarm Status
		8. Parking Lot or Exterior Lights
			1. On/Off Control
		9. Emergency Generator
			1. Generator Run Status
			2. Transfer Switch Status
			3. Generator Fault Alarm
	10. Training
		1. Provide demonstration and training in accordance with Section 01 79 00.

END OF SECTION