SECTION 230923.27 - TEMPERATURE INSTRUMENTS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

1. GENERAL
	* + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
			1. SUMMARY
				1. Section Includes:

Air temperature sensors.

Combination air temperature sensors and switches.

Air temperature switches.

Air temperature RTD transmitters.

Liquid and steam temperature sensors.

High-end, commercial-grade, liquid and steam temperature sensors.

Industrial-grade liquid and steam temperature sensors.

Liquid temperature switches.

High-end, commercial-grade, liquid and steam temperature transmitters.

Industrial-grade liquid and steam temperature transmitters.

* + - * 1. Related Requirements:

Retain subparagraphs below to cross-reference requirements Contractor might expect to find in this Section but are specified in other Sections.

Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.27.

* + - 1. DEFINITIONS

Retain terms that remain after this Section has been edited for a project.

* + - * 1. HART (Highway Addressable Remote Transducer) Protocol: The global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bidirectional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from a technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.
				2. RTD: Resistance temperature detector.
			1. SUBMITTALS
				1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
				2. Manufacturer’s installation instructions shall be provided along with product data.
				3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
				4. Product Data: For each type of product, including the following:

Construction details, material descriptions, dimensions of individual components and profiles, and finishes.

Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.

Product description with complete technical data, performance curves, and product specification sheets.

Installation operation and maintenance instructions, including factors affecting performance.

* + - * 1. Shop Drawings:

Include plans, elevations, sections, and[**mounting**] details.

Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

Include diagrams for power, signal, and control wiring.

Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

Retain "Samples" paragraph below for single-stage Samples, with a subordinate list if applicable.

* + - * 1. Samples: For each exposed product installed in finished space.

Retain "Coordination Drawings" paragraph below for situations where limited space necessitates maximum utilization for efficient installation of different components or if coordination is required for installation of products and materials by separate installers. Coordinate paragraph with other Sections specifying products listed below. Preparation of coordination drawings requires the participation of each trade involved in installations within the limited space.

* + - * 1. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

Product installation location shown in relationship to room, duct, pipe, and equipment.

Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.

Sizes and locations of wall access panels for instruments installed behind walls.

Sizes and locations of ceiling access panels for instruments installed in inaccessible ceilings.

Retain "Product Certificates" paragraph below to require submittal of product certificates from manufacturers.

* + - * 1. Product Certificates: For each product requiring a certificate.
				2. Product Test Reports: For each product, for tests performed by [**manufacturer and witnessed by a qualified testing agency**] [**a qualified testing agency**].

Retain "Field quality-control reports" paragraph below if Contractor is responsible for field quality-control testing and inspecting.

* + - * 1. Field quality-control reports.
			1. MAINTENANCE MATERIAL SUBMITTALS
				1. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

Retain paragraph below for spare product inventory.

* + - * 1. Provide [**one**] [**two**] <**Insert quantity**> matching product(s) in Project inventory for each unique size and type of the following:

<**Insert product**>.

1. PRODUCTS

See Editing Instruction No. 1 in the Evaluations for cautions about named manufacturers and products.

* + - 1. PERFORMANCE REQUIREMENTS
				1. Environmental Conditions:

Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated[**and cooled**], filtered, and ventilated as required by instrument and application.

Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:

Outdoors, Protected: [**Type 2**] [**Type 3**] [**Type 12**] <**Insert type**>.

Outdoors, Unprotected: [**Type 4**] [**Type 4X**].

Indoors, Heated with Filtered Ventilation: [**Type 1**] [**Type 2**] <**Insert type**>.

Indoors, Heated with Non-Filtered Ventilation: [**Type 2**] [**Type 12**] <**Insert type**>.

Indoors, Heated and Air Conditioned: [**Type 1**] <**Insert type**>.

Mechanical Equipment Rooms:

Chiller and Boiler Rooms: [**Type 12**] [**Type 4**] [**Type 4X**] <**Insert type**>.

Air-Moving Equipment Rooms: [**Type 1**] [**Type 2**] [**Type 12**] <**Insert type**>.

Localized Areas Exposed to Washdown: [**Type 4**] [**Type 4X**] <**Insert type**>.

Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: [**Type 2**] [**Type 3**] [**Type 12**] <**Insert type**>.

Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: [**Type 4**] [**Type 4X**] <**Insert type**>.

Hazardous Locations: Explosion-proof rating for condition.

<**Insert location and enclosure requirements**>.

* + - 1. AIR TEMPERATURE SENSORS
				1. Platinum RTDs: Common Requirements:

100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.

Two-wire, PTFE-insulated, 22-gage stranded copper leads.

Performance Characteristics:

Range: Minus 50 to 275 deg F.

Interchangeable Accuracy: At 32 deg F within 0.5 deg F.

Repeatability: Within 0.5 deg F.

Self-Heating: Negligible.

Transmitter Requirements:

Transmitter required for each 100-ohm RTD.

Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

* + - * 1. Platinum RTD, Single-Point Air Temperature Duct Sensors:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in seven subparagraphs below are based on Minco's "S400 Series PD or PF."

[**100**] [**or**] [**1000**] ohms.

Temperature Range: Minus 50 to 275 deg F

Probe: Single-point sensor with a stainless-steel sheath.

Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.

Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.

Gasket for attachment to duct or equipment to seal penetration airtight.

Conduit Connection: 1/2-inch

* + - * 1. Platinum RTD, Air Temperature Averaging Sensors:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in nine subparagraphs below are based on Minco's "S400 Series PD or PF."

[**100**] [**or**] [**1000**] ohms.

Temperature Range: Minus 50 to 275 deg F

Multiple sensors to provide average temperature across entire length of sensor.

Rigid probe of aluminum, brass, copper, or stainless-steel sheath.

Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.

Length: As required by application to cover entire cross section of air tunnel.

Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.

Gasket for attachment to duct or equipment to seal penetration airtight.

Conduit Connection: 1/2-inch

* + - * 1. Platinum RTD Outdoor Air Temperature Sensors:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in six subparagraphs below are based on Minco's "S400 Series PD or PF."

[**100**] [**or**] [**1000**] ohms.

Temperature Range: Minus 50 to 275 deg F

Probe: Single-point sensor with a stainless-steel sheath.

Solar Shield: Stainless steel.

Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.

Conduit Connection: 1/2-inch trade size.

* + - * 1. Platinum RTD Space Air Temperature Sensors:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on Minco's "S400 Series PD or PF."

[**100**] [**or**] [**1000**] ohms.

Temperature Range: Minus 50 to 212 deg F

Sensor assembly shall include a temperature sensing element mounted under a [**bright white, non-yellowing, plastic**] [**flush, brushed-aluminum**] cover.

Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.

Concealed wiring connection.

* + - * 1. Thermal Resistors (Thermistors): Common Requirements:

10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.

Two-wire, PTFE-insulated, 22-gage stranded copper leads.

Performance Characteristics:

Range: Minus 50 to 275 deg F.

Interchangeable Accuracy: At 77 deg F within 0.5 deg F.

Repeatability: Within 0.5 deg F.

Drift: Within 0.5 deg F over 10 years.

Self-Heating: Negligible.

Transmitter optional, contingent on compliance with end-to-end control accuracy.

* + - * 1. Thermistor, Single-Point Duct Air Temperature Sensors:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on Minco's "TS400 Series TB."

Temperature Range: Minus 50 to 275 deg F

Probe: Single-point sensor with a stainless-steel sheath.

Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.

Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.

Gasket for attachment to duct or equipment to seal penetration airtight.

Conduit Connection: 1/2- inch trade size.

* + - * 1. Thermistor Averaging Air Temperature Sensors:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on Minco's "TS400 Series TB."

Temperature Range: Minus 50 to 275 deg F

Multiple sensors to provide average temperature across entire length of sensor.

Rigid probe of aluminum, brass, copper, or stainless-steel sheath.

Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.

Length: As required by application to cover entire cross section of air tunnel.

Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.

Gasket for attachment to duct or equipment to seal penetration airtight.

Conduit Connection: 1/2-inch trade size.

* + - * 1. Thermistor Outdoor Air Temperature Sensors:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on Minco's "TS400 Series TB."

Temperature Range: Minus 50 to 275 deg F

Probe: Single-point sensor with a stainless-steel sheath.

Solar Shield: Stainless steel.

Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.

Conduit Connection: 1/2-inch trade size.

* + - * 1. Thermistor Space Air Temperature Sensors:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on Minco's "TS400 Series TB."

Temperature Range: Minus 50 to 212 deg F

Sensor assembly shall include a temperature sensing element mounted under a [**bright white, non-yellowing, plastic**] [**flush, brushed-aluminum**] cover.

Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.

Concealed wiring connection.

* + - * 1. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units:

[**100-**] [**or**] [**1000-**]ohm platinum RTD[**or thermistor**].

Retain "Thermistor" subparagraph below if retaining fourth option in "Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units" paragraph above.

Thermistor:

Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.

Thermistor drift shall be less than plus or minus 0.5 deg F over 10 years.

Temperature Transmitter Requirements:

Mating transmitter required with each 100-ohm RTD.

Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.

Retain first subparagraph below for local display of temperature.

Provide digital display of sensed temperature.

Retain subparagraph below for local control feature.

Provide sensor with local control.

Local override to turn HVAC on.

Local adjustment of temperature set point.

Both features shall be capable of manual override through control system operator.

* + - 1. COMBINATION AIR TEMPERATURE SENSOR AND SWITCH
				1. Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

* + - * 1. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

Requirements in remaining paragraphs are based on Minco's "Model AS103759 PF38EXXB2L."

* + - * 1. Combination temperature sensor and switch in same instrument.
				2. Air Temperature Switch:

Factory preset set point of 38 deg F. Field-adjustable set point from 30 to 44 deg F.

Responsive to coldest 12-inch section of sensor length.

DPST latching relay rated at 25 A and 120-V ac, with powered controller, coil, and manual rest at panel. Wire one leg to fan start circuit and other leg to signal a remote alarm.

* + - * 1. Air Temperature Sensor:

Temperature-averaging type over sensor length. Length to be determined by installing trade to provide uniform coverage over air tunnel. Consult manufacturer for recommendations.

Platinum RTD with a value of 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.

Accuracy: Within 0.9 deg F.

Output Signal: 4 to 20 mA for connection to remote monitoring.

Encase RTDs in a flexible nominal 0.375-inch- diameter sheath constructed of brass.

Lead wires shall be 18-gage AWG copper.

Enclosure: NEMA 250, Type 4.

* + - 1. AIR TEMPERATURE SWITCHES
				1. Thermostat and Switch for Low Temperature Control in Duct Applications:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Honeywell International Inc.

Johnson Controls

Siemens Industry, Inc., Building Technologies Division.

Approved equivalent.

Requirements in remaining subparagraphs are based on Honeywell's "L482A" or Siemens; 134-1504."

Description:

Two-position control.

Field-adjustable set point.

Manual reset.

Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

Performance:

Operating Temperature Range: 15 to 55 deg F.

Temperature Differential: 5 deg F, non-adjustable and additive.

Enclosure Ambient Temperature: Minus 20 to 140 deg F.

Sensing Element Maximum Temperature: 250 deg F.

Voltage: 120-V ac.

Current: 16 FLA.

Switch Type: Two SPDT snap switches operate on coldest 12-inchsection along element length.

Construction:

Vapor-Filled Sensing Element: Nominal 20 feetlong.

Dual Temperature Scale: Fahrenheit and Celsius visible on face.

Set-Point Adjustment: Screw.

Enclosure: Painted metal, NEMA 250, Type 1.

Electrical Connections: Screw terminals.

Conduit Connection: 1/2-inch trade size.

* + - * 1. Thermostat and Switch for High Temperature Control in Duct Applications:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Schneider Electric USA, Inc.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

Requirements in remaining subparagraphs are based on TAC's "Model TA-3433."

Description:

Two-position control.

Field-adjustable set point.

Manual reset.

Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

Performance:

Temperature Range: 100 to 160 deg F.

Temperature Differential: 5 deg F.

Ambient Temperature: Zero to 260 deg F.

Voltage: 120-V ac.

Current: 16 FLA.

Switch Type: SPDT snap switch.

Construction:

Sensing Element: Helical bimetal.

Enclosure: Metal, NEMA 250, Type 1.

Electrical Connections: Screw terminals.

Conduit Connection: 1/2-inch trade size.

* + - 1. AIR TEMPERATURE RTD TRANSMITTERS
				1. Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

* + - * 1. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

Requirements in remaining paragraphs are based on Minco's "TT Series."

* + - * 1. House electronics in NEMA 250 enclosure.

Duct: [**Type 1**] [**Type 2**] [**Type 3**].

Outdoor: [**Type 4**] [**or**] [**Type 4X**].

Space: Type 1.

* + - * 1. Conduit Connection: 1/2-inch
				2. Functional Characteristics:

Input:

100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.

1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.

Span (Adjustable):

Space: 40 to 90 deg F.

Supply Air Cooling and Heating: 40 to 120 deg F.

Supply Air Cooling Only: 40 to 90 deg F.

Supply Air Heating Only: 40 to 120 deg F.

Exhaust Air: 50 to 100 deg F.

Return Air: 50 to 100 deg F.

Mixed Air: Minus 40 to 140 deg F.

Outdoor: Minus 40 to 140 deg F.

Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc .

Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.

Match sensor with temperature transmitter and factory calibrate together.

* + - * 1. Performance Characteristics:

Calibration Accuracy: Within 0.1 percent of the span.

Stability: Within 0.2 percent of the span for at least 6 months.

Combined Accuracy: Within 0.5 percent.

* + - 1. LIQUID AND STEAM TEMPERATURE SENSORS, COMMERCIAL GRADE
				1. RTD:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

MAMAC Systems, Inc.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on "MAMAC's "703D Series."

If selecting "100" option in "Description" subparagraph below, provide mating transmitter for desired accuracy over distance greater than 25 feet.

Description:

Platinum with a value of [**100**] [**or**] [**1000**] ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.

Encase RTD in a stainless-steel sheath with a 0.25-inch OD.

Sensor Length: 4, 6, or 8 inches as required by application.

Process Connection: Threaded, NPS 1/2

Two-stranded copper lead wires.

Powder-coated steel enclosure, NEMA 250, Type 4.

Conduit Connection: 1/2-inch

Performance Characteristics:

Range: Minus 40 to 210 deg F.

Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.

* + - * 1. Thermowells:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

MAMAC Systems, Inc.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on "MAMAC's "A500 Series."

Stem: [**Straight**] [**or**] [**stepped**] shank formed from solid bar stock.

Material: [**Brass**] [**or**] [**stainless steel**].

Process Connection: Threaded, NPS 3/4.

Sensor Connection: Threaded, NPS 1/2.

Bore: Sized to accommodate sensor with tight tolerance between sensor and well.

Furnish thermowells installed in insulated pipes and equipment with an extended neck.

Length: 4, 6, or 8 inches as required by application.

Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

* + - 1. LIQUID AND STEAM TEMPERATURE SENSORS, HIGH-END COMMERCIAL GRADE
				1. RTD:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on Minco's "RTD Series."

Resistance temperature sensors shall comply with IEC 60751, Class B requirements.

Platinum with a value of 100 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.

Encase RTD in a Type 316 stainless-steel sheath with a 0.25-inch OD.

Provide [**two**] [**three**] [**four**]-wire, PTFE-insulated, nickel-coated, 22-gage, stranded copper leads.

Retain first subparagraph below for spring-loaded holder. Spring-loaded holder provides direct connect with thermowell for improved temperature measurement.

Provide spring-loaded RTDs for thermowell installations.

Performance Characteristics:

Range: Minus 328 to 932 deg F.

Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.

Stability: Within 0.05 percent maximum ice-point resistance shift after 1000 hours at 752 deg F.

Hysteresis: Within 0.04 percent of range.

Response Time: 62.8 percent of change in 4 seconds with water flowing across sensor at 3 fps.

* + - * 1. Thermowells:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on Minco's "TW Series."

Stem: [**Straight**] [**or**] [**stepped**] [**or**] [**tapered**] shank formed from solid bar stock.

Material: [**Type 304**] [**or**] [**Type 316**] stainless steel.

Process Connection: Threaded, NPS 3/4

Sensor Connection: Threaded, NPS 1/2

Bore: Sized to accommodate sensor with tight tolerance between sensor and well.

Furnish thermowells installed in insulated pipes and equipment with an extended neck that extends beyond the face of the insulation covering.

Length: As required by application and pipe size.

Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

* + - * 1. Connection Heads:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on Minco's "CH 359 Connection Head."

Housing: Low-copper cast-aluminum alloy, complying with NEMA 250, Type 4.

Terminals: Six or eight as required by sensor.

Conduit Connection: 1/2-inch trade size.

Sensor Connection: NPS 1/2.

* + - * 1. Assembly: Sensor manufacturer shall furnish sensor, thermowell, and sensor connection head to provide a matched assembly.
			1. LIQUID AND STEAM TEMPERATURE SENSORS, INDUSTRIAL GRADE
				1. RTD:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Rosemount; Emerson Process Management.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on Rosemount's "Series 78S."

Resistance temperature sensors shall comply with IEC 60751, Class A requirements.

Platinum with a value of 100 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.

Encase RTD in a Type 316 stainless-steel sheath with a 0.25-inch OD.

Provide [**two**] [**three**] [**four**]-wire, PTFE-insulated, nickel-coated, 22-gage, stranded copper leads.

Retain first subparagraph below for spring-loaded tip on end of RTD. Spring-loaded tip provides direct connect with thermowell for improved temperature measurement.

Provide spring-loaded RTDs for thermowell installations.

Performance Characteristics:

Range: Minus 328 to 932 deg F.

Interchangeable Accuracy: Within 0.27 deg F at 32 deg F.

Stability: Within 0.05 percent maximum ice-point resistance shift after 1000 hours at 752 deg F.

Hysteresis: Within 0.04 percent of range.

Response Time: 62.8 percent of change in 4 seconds with water flowing across sensor at 3 fps.

Self-Heating: 18-mW minimum power dissipation required to cause a 1.8 deg F temperature measurement error in water flowing at 3 fps.

* + - * 1. Thermowells:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Rosemount; Emerson Process Management.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on Rosemount's "Series 91."

Stem: [**Straight**] [**or**] [**stepped**] [**or**] [**tapered**] shank formed from solid bar stock.

Material: [**Type 304**] [**or**] [**Type 316**] stainless steel.

Process Connection: Threaded, NPS 3/4, or flange-face, [**NPS 1**] [**NPS 1-1/2**] [**NPS 2**], [**Class 150**] [**Class 300**] ASME B16.5.

Sensor Connection: Threaded, NPS 1/2.

Bore: Sized to accommodate sensor with tight tolerance between sensor and well.

Furnish thermowells installed in insulated pipes and equipment with an extended neck that extends beyond the face of the insulation covering.

Length: As required by application and pipe size.

Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

* + - * 1. Connection Heads:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Rosemount; Emerson Process Management.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on Rosemount's "Connection Head."

Housing: Low-copper cast-aluminum alloy, complying with NEMA 250, Type 4.

Terminals: Six or eight as required by sensor, nickel-plated brass.

Conduit Connection: 1/2-inch trade size.

Sensor Connection: Threaded, NPS 1/2.

* + - * 1. Assembly: Sensor manufacturer shall furnish sensor, thermowell, and sensor connection head to provide a matched assembly.
			1. LIQUID TEMPERATURE SWITCHES
				1. Thermostat and Switch for Temperature Control in Pipe Applications:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Honeywell International Inc.

Johnson Controls

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs are based on Honeywell's "L6006C."

Description:

Two-position control.

Field-adjustable set point.

Manual reset.

Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

Performance:

Operating Temperature Range: 65 to 200 deg F.

Temperature Differential Deadband: 5 to 30 deg F, adjustable.

Enclosure Ambient Temperature: 150 deg F.

Sensing Element Pressure Rating: 200 psig.

Voltage: 120-V ac.

Current: 8 FLA.

Switch Type: SPDT snap switch.

Construction:

Vapor-Filled Immersion Element: Copper, nominal 3 inches long.

Temperature Scale: Fahrenheit, visible on face.

Set-Point Adjustment: Screw.

Enclosure: Painted metal, NEMA 250, Type 1.

Electrical Connections: Screw terminals.

Conduit Connection: 3/4-inch.

* + - 1. LIQUID AND STEAM TEMPERATURE TRANSMITTERS, COMMERCIAL GRADE
				1. Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Minco.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining paragraphs are based on Minco's "TT Series."

* + - * 1. House electronics in NEMA 250, [**Type 4**] [**or**] [**Type 4X**] enclosure.
				2. Enclosure Connection: 1/2-inch trade size.
				3. Functional Characteristics:

Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, [**two-**] [**or**] [**three-**]wire sensors.

Default Span (Adjustable):

Chilled Water: Zero to 100 deg F.

Condenser Water: Zero to 120 deg F.

Heating Hot Water: 32 to 212 deg F.

Heat Recovery: Zero to 120 deg F.

<**Insert system and span**>.

Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.

Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.

Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.

* + - * 1. Performance Characteristics:

Calibration Accuracy: Within 0.1 percent of the span.

Stability: Within 0.2 percent of the span for at least 6 months.

Combined Accuracy: Within 0.5 percent.

* + - 1. LIQUID AND STEAM TEMPERATURE TRANSMITTERS, INDUSTRIAL GRADE
				1. Manufacturers: Subject to compliance with requirements, provide products by the following:

Johnson Controls

Rosemount; Emerson Process Management.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining paragraphs are based on Rosemount's "Model 644."

Retain "Hazard Classification" paragraph below for hazardous environments.

* + - * 1. Hazard Classification: FM Approved for hazardous environments.

Intrinsically safe for Classes I, II, and III; Division 1; Groups A through G.

Explosion proof for Class I; Division 1; Groups B, C, and D.

Dust-ignition proof for Classes II and III; Division 1; Groups E, F, and G.

* + - * 1. Performance:

Digital Accuracy: Within 0.27 deg F with a 180 deg F span.

Digital to Analog Accuracy: Within 0.03 percent of span.

Total Accuracy: Within 0.32 deg F with a 180 deg F span.

Stability: Within 0.15 percent of output reading for 24 months.

Ambient Temperature Limits: Minus 4 to 185 deg F.

Humidity Limits: Zero to 99 percent.

* + - * 1. Electronics Enclosure:

Materials: Aluminum alloy or stainless steel.

NEMA 250, Type 4X enclosure.

Conduit Connections: 1/2-inch trade size.

Mounting kit to suit application.

* + - * 1. Functional Characteristics:

Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C.

Range: Minus 328 to 1562 deg F.

Field-Adjustable Span: 18 deg F minimum.

Default Spans:

Chilled Water: Zero to 100 deg F.

Condenser Water: Zero to 120 deg F.

Heating Hot Water: 32 to 212 deg F.

Heat Recovery: Zero to 120 deg F.

<**Insert system and span**>.

Output Signal:

4- to 20-mA dc, linear with temperature.

Digital signal based on HART protocol carried with current signal.

RFI insensitive.

Minimum drive load of 600 ohms at 24-V dc.

Self-Calibration: The analog-to-digital measurement circuitry automatically self-calibrates for each temperature update by comparing the dynamic measurement to extremely stable and accurate internal reference elements.

Retain subparagraph below for optional display.

Digital display of engineering units.

1. EXECUTION
	* + 1. EXAMINATION
				1. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
				2. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
				3. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
				4. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
				5. Proceed with installation only after unsatisfactory conditions have been corrected.

Options indicated in "Temperature Instrument Applications" Article are provided where multiple product options are specified. Delete Article if only a single product is specified for an instrument type.

* + - 1. TEMPERATURE INSTRUMENT APPLICATIONS

Retain this article unless instrument types are indicated on Drawings.

* + - * 1. Air Temperature Sensors:

Copy and edit subparagraphs below to suit each unique application requiring a different sensor type.

Duct, <**Insert application**>: [**Thermistor**] [**100-ohm platinum RTD**] [**1000-ohm platinum RTD**].

Outdoor, <**Insert application**>: [**Thermistor**] [**100-ohm platinum RTD**] [**1000-ohm platinum RTD**].

Space, <**Insert application**>: [**Thermistor**] [**100-ohm platinum RTD**] [**1000-ohm platinum RTD**].

* + - * 1. Air Temperature Transmitters:

Copy and edit subparagraphs below to suit each unique application requiring a different sensor type.

Duct, <**Insert application**>: [**Not required**] [**Air temperature RTD transmitter**].

Outdoor, <**Insert application**>: [**Not required**] [**Air temperature RTD transmitter**].

Space, <**Insert application**>: [**Not required**] [**Air temperature RTD transmitter**].

* + - * 1. Liquid and Steam Temperature Sensors:

Copy and edit subparagraph below to suit each system and unique applications requiring a different type of liquid temperature sensor. Where "<Insert system>" is indicated, insert system type such as "chilled-water," "condenser-water," "heat-recovery," "hot-water," or "steam." Where "<Insert unique application>" is indicated, insert unique requirement such as equipment class, or if common to all, insert "General."

<**Insert system**> System, <**Insert unique application**>: [**Liquid and steam temperature sensor, commercial grade**] [**Liquid and steam temperature sensor, high-end commercial grade**] [**Liquid and steam temperature sensor, industrial grade**].

* + - * 1. Liquid and Temperature Transmitters:

Copy and edit subparagraph below to suit each system and unique applications requiring a different type of liquid temperature transmitter. Where "<Insert system>" is indicated, insert system type such as "chilled-water," "condenser-water," "heat-recovery," "hot-water," or "steam." Where "<Insert unique application>" is indicated, insert unique requirement such as equipment class, or if common to all, insert "General."

<**Insert system**> System, <**Insert unique application**>: [**Liquid and steam temperature transmitter, commercial grade**] [**Liquid and steam temperature transmitter, industrial grade**].

* + - 1. INSTALLATION, GENERAL
				1. Install products level, plumb, parallel, and perpendicular with building construction.
				2. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a <**Insert value**> force.
				3. Fastening Hardware:

Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.

Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.

Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

* + - * 1. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Director’s Representative's access, confirm unrestricted ladder placement is possible under occupied condition.
				2. Corrosive Environments:

Use products that are suitable for environment to which they are subjected.

If possible, avoid or limit use of materials in corrosive environments.

When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.

Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

* + - 1. ELECTRIC POWER
				1. Provide electrical power to products requiring electrical connections.
				2. Provide circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
				3. Provide power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
				4. Provide raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."
			2. TEMPERATURE INSTRUMENT INSTALLATIONS
				1. Mounting Location:

Roughing In:

Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.

Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.

Do not begin installation without submittal approval of mounting location.

Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Director’s Representative and Architect on request.

Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.

Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

* + - * 1. Special Mounting Requirements:

Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of [**Type 316 stainless**] <**Insert material**>.

Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

* + - * 1. Mounting Height:

Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.

Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

Make every effort to mount at 60 inches.

* + - * 1. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.
				2. Space Temperature Sensor Installation:

Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.

Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.

In finished areas, recess electrical box within wall.

In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.

Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

* + - * 1. Outdoor Air Temperature Sensor Installation:

Mount sensor in a discrete location facing north.

Protect installed sensor from solar radiation and other influences that could impact performance.

If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

* + - * 1. Single-Point Duct Temperature Sensor Installation:

Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.

Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.

Rigidly support sensor to duct and seal penetration airtight.

If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

* + - * 1. Averaging Duct Temperature Sensor Installation:

Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger.

Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.

Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.

If required to have transmitter, mount transmitter in an accessible and serviceable location.

* + - * 1. Low-Limit Air Temperature Switch Installation:

Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.

Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.

Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.

Install on entering side of cooling coil unless otherwise indicated on Drawings.

* + - * 1. Liquid Temperature Sensor Installation:

Assembly shall include sensor, thermowell[**and connection head**].

For pipe NPS 4 and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.

For pipe smaller than NPS 4:

Install reducers to increase pipe size to NPS 4at point of thermowell installation.

For pipe sizes NPS 2-1/2 and NPS 3, thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.

Minimum insertion depth shall be 2-1/2 inches.

Install matching thermowell.

Fill thermowell with heat-transfer fluid before inserting sensor.

Tip of spring-loaded sensors shall contact inside of thermowell.

For insulated piping, install thermowells with extension neck to extend beyond face of insulation.

Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.

For applications with transmitters, mount transmitter remote from sensor in an accessible and serviceable location from floor[**service platform or catwalk**].

* + - 1. IDENTIFICATION
				1. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
				2. Install engraved phenolic nameplate with instrument identification[**and on face of ceiling directly below instruments concealed above ceilings**].
			2. CLEANING
				1. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.
				2. Wash and shine glazing.
				3. Polish glossy surfaces to a clean shine.
			3. CHECK-OUT PROCEDURES
				1. Check installed products before continuity tests, leak tests, and calibration.
				2. Check temperature instruments for proper location and accessibility.
				3. Verify sensing element type and proper material.
				4. Verify location and length.
				5. Verify that wiring is correct and secure.
			4. ADJUSTMENT, CALIBRATION, AND TESTING
				1. Description:

Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.

Provide diagnostic and test equipment for calibration and adjustment.

Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

* + - * 1. Analog Signals:

Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.

Check analog current signals using a precision current meter at zero, 50, and 100 percent.

Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

* + - * 1. Digital Signals:

Check digital signals using a jumper wire.

Check digital signals using an ohmmeter to test for contact.

* + - * 1. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
				2. Switches: Calibrate switches to make or break contact at set points indicated.
				3. Transmitters:

Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.

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

* + - 1. FIELD QUALITY CONTROL

Retain "Testing Agency," "Manufacturer's Field Service," and "Perform the following tests and inspections" paragraphs below to identify who shall perform tests and inspections. If retaining second option in "Testing Agency" paragraph or if retaining "Manufacturer's Field Service" or "Perform the following tests and inspections" paragraph, retain "Field quality-control reports" paragraph in "Informational Submittals" Article.

* + - * 1. Testing Agency: [**Director’s Representative will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

Retain "Manufacturer's Field Service" paragraph below to require a factory-authorized service representative to perform tests and inspections.

* + - * 1. Manufacturer's Field Service: Engage a company field advisor to test and inspect components, assemblies, and installations, including connections.

Retain "Perform the following tests and inspections" paragraph below to require Contractor to perform tests and inspections.

* + - * 1. Perform the following tests and inspections[**with the assistance of a company field advisor**]:

Perform according to manufacturer's written instruction.

Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

* + - * 1. Prepare test and inspection reports.
			1. ADJUSTING
				1. Occupancy Adjustments: When requested within [**12**] <**Insert number**> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [**two**] <**Insert number**> visits to Project during other-than-normal occupancy hours for this purpose.
			2. MAINTENANCE SERVICE

Verify with Owner that maintenance service is required for Project.

* + - * 1. Maintenance Service: In addition to the contractors 1-year project warranty requirements, beginning at Substantial Completion, maintenance service shall include [**three**] [**six**] [**nine**] [**12**] months' full maintenance by [**skilled employees of systems and equipment Installer**] [**manufacturer's authorized service representative**]. Include [**monthly**] [**quarterly**] [**semiannual**] [**annual**] preventive maintenance, repair or replacement of worn or defective components, cleaning and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
			1. DEMONSTRATION
				1. [**Engage a company field advisor to train**] [**Train**] Director’s Representative's maintenance personnel to adjust, operate, and maintain temperature instruments.
				2. Provide a complete set of instructional videos covering each product specified and installed and showing the following:

Software programming.

Calibration and test procedures.

Operation and maintenance requirements and procedures.

Troubleshooting procedures.

* + - * 1. Coordinate video with operation and maintenance manuals and classroom instruction for use by Director’s Representative in operating, maintaining, and troubleshooting.
				2. Record videos on DVD disks.
				3. Director’s Representative shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.27