SECTION 230923.14 - FLOW 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:

Airflow measurement stations and sensors.

Airflow switches.

Airflow transmitters.

Liquid flow meters.

Liquid flow sensors.

Liquid flow switches.

Liquid flow 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 230923.14.

* + - 1. DEFINITIONS

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

* + - * 1. Ethernet: Local area network based on IEEE 802.3 standards.
				2. FEP: Fluorinated ethylene propylene.
				3. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.
				4. PEEK: Polyetheretherketone.
				5. PTFE: Polytetrafluoroethylene.
				6. PPS: Polyphenylene sulfide.
				7. RS-485: A TIA standard for multipoint communications using two twisted pairs.
				8. RTD: Resistance temperature detector.
				9. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
			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 instructions, including factors affecting performance.

Product certificates.

* + - * 1. Sustainable Design Submittals:
				2. 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 diagrams for air and process signal tubing.

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

Retain "Delegated-Design Submittal" paragraph below if design services have been delegated to Contractor.

* + - * 1. Delegated-Design Submittal:

Schedule and design calculations for flow instruments, including the following.

Flow at Project design and minimum flow conditions.

Pressure drop at Project design and minimum flow conditions.

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

* + - * 1. Product Certificates: For each product requiring a certificate.

Requirements in "Product Test Reports" paragraph below are for test reports for products on which tests are performed either by independent testing agencies or by manufacturers in their own labs. Retain first option below if testing is likely to be performed in manufacturer's facilities and witnessed by a qualified testing agency; retain second option if testing is performed by the testing agency.

* + - * 1. Product Test Reports: For each product, for tests performed by [**manufacturer and witnessed by a qualified testing agency**] [**a qualified testing agency**].
			1. CLOSEOUT SUBMITTALS
				1. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.
			2. 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 product parts inventory over extended operating period.

* + - * 1. Provide parts, as indicated by manufacturer's recommended parts list, for product operation during [**one**] [**two**] <**Insert number**>-year period following warranty period.
1. PRODUCTS

See Editing Instruction No. 1 in the Evaluations for cautions about named manufacturers and products. For an explanation of options and Contractor's product selection procedures, see Section 016000 "Product Requirements."

* + - 1. PERFORMANCE REQUIREMENTS

Retain "Delegated Design" Paragraph below if Contractor is required to assume responsibility for design.

* + - * 1. Delegated Design: Select and size products to achieve specified performance requirements.
				2. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
			1. GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS
				1. Air sensors and transmitters shall have an extended range of [**10**] [**20**] <**Insert number**> percent above Project design flow and [**10**] [**20**] <**Insert number**> percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.
				2. Liquid and steam sensors, meters, and transmitters shall have an extended range of [**10**] [**20**] <**Insert number**> percent above Project design flow and [**10**] [**20**] <**Insert number**> percent below Project minimum flow to signal abnormal flow conditions and to provide flexibility for changes in operation.
				3. Source Limitations: For flow instruments, obtain products from single source from single manufacturer.
			2. AIRFLOW MEASUREMENT STATIONS AND SENSORS
				1. Performance Requirements:

Adjustable for changes in system operational parameters.

Airflow Sensor and Transmitter Range: Extended range of [**10**] [**20**] <**Insert number**> percent above Project design flow and [**10**] [**20**] <**Insert number**> percent below minimum Project flow to signal abnormal flow conditions.

Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.

Product certificates are required.

* + - * 1. Thermal Airflow Measurement Stations:

Common Performance Requirements:

Provide stations that are adjustable for changes in system operational parameters.

Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.

Thermal airflow stations with one or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location.

Sensor Nodes: One self-heated and one zero-power bead-in-glass thermistor, using the principle of thermal dispersion.

Airflow Rate and Temperature of Each Sensor: Equally weighted and averaged by the transmitter prior to output.

Sensor-Node and Probe Assemblies:

Sensor-Node Construction: Two bead-in-glass, hermetically sealed thermistors potted in a marine-grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene. Construct with only the thermistor located within the sensing node and all other electronic components outside the airstream. Epoxy- or glass-encapsulated chip thermistors or devices with exposed leads are not allowed. Devices that use epoxy- or glass-encapsulated chip thermistors, or electronics in the airstream, are unacceptable. Devices with exposed leads are unacceptable.

Store sensor-node airflow and temperature calibration data in a serial memory chip, in the cable connecting plug. Stored data does not require matching or adjustments to the transmitter in the field.

Sensing-Node Temperature Accuracy: Within 0.15 deg F (0.08 deg C) over an operating range of minus 20 to plus 160 deg F (minus 28.9 to plus 71.1 deg C) and humidity range of 0 to 100 percent RH.

Sensor-Probe Mounting Bracket Construction: Type 304 stainless steel.

Internal Probe Wiring: Kynar-coated copper between the connecting cable and sensor nodes. PVC-jacketed wiring is unacceptable.

Internal Probe Wiring Connections: Solder joints and spot welds, sealed and protected from the elements, so that direct exposure to water will not affect instrument operation. Connectors within the probe, of any type, are unacceptable. Printed circuit boards within the probe are unacceptable.

Sensor-Probe Jacket: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from minus 67 to plus 392 deg F (minus 55 to plus 200 deg C), and for continuous and direct UV exposure. Plenum-rated PVC jacket cables are unacceptable.

Sensor-Probe Cable Connector Plug: Gold-plated pins for connection to the transmitter.

Transmitter Features and Functions:

High and/or low airflow alarm with user-defined set point and percent of set-point tolerance.

Manual or automatic alarm reset, and low-limit cutoff value may be selected to disable the alarm.

Alarm delay function, field defined.

Sensor-node malfunction via the system status alarm and ignore the sensor node that is in a fault condition.

Field configuration, diagnostics, and field output adjustment wizard that allow for a one- or two-point field adjustment to factory calibration for installations that require adjustment.

Automatic reset after power disruption, transients, and brown-outs through a watchdog timer circuit.

Operating temperature range of minus 20 to plus 120 deg F (minus 28.9 to plus 48.9 deg C) and humidity range of 5 to 95 percent RH.

Electrical Power Requirement: 24 V ac (between 22.8 and 26.4 V ac under load) at 20 VA maximum, using a switching power supply that is overcurrent and overvoltage protected.

Printed Circuit Board Interconnects: Gold-plated edge fingers, receptacle plug pins, and printed circuit board test points.

Printed Circuit Boards: Electroless nickel immersion gold (ENIG) plated.

Integrated Circuitry: Temperature-rated, industrial-grade. Commercial-grade integrated circuitry is not acceptable.

Integration Buffers: Separate integration buffers for display of airflow output, airflow signal output (analog and network), and individual sensor output (IR-interface).

Retain "For Air-Ducted/Plenum" Subparagraph below for airflow measurement in all sizes of ducts or plenums when systems require analog and network outputs.

For Air-Ducted/Plenum:

Airflow Station Performance:

Independent processing of up to [**16**] <**Insert number**> separately wired sensor-node assemblies.

Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

Sensor-Node and Probe Assemblies:

Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory results.

Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm (0 to 25.4 m/s).

Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

Provide the number of independent sensor nodes as follows:

For Duct/Plenum Area up to 0.5 sq. ft. (0.046 sq. m): One.

For Duct/Plenum Area Greater Than 0.5 through 1.0 sq. ft. (0.046 through 0.092 sq. m): Two.

For Duct/Plenum Area Greater Than 2.0 through 4.0 sq. ft. (0.186 through 0.372 sq. m): Six.

For Duct/Plenum Area Greater Than 4.0 through 8.0 sq. ft. (0.372 through 0.743 sq. m): Eight.

For Duct/Plenum Area Greater Than 8.0 through 12.0 sq. ft. (0.743 through 1.11 sq. m): 12.

For Duct/Plenum Area Greater Than 12.0 through 14.0 sq. ft. (1.11 through 1.30 sq. m): 14.

For Duct/Plenum Area Greater Than 14.0 sq. ft. (1.30 sq. m): 16.

For an aspect ratio of 1.5 or less, and an area of 25 sq. ft. (2.32 sq. m) or greater, four probes are required.

Sensor-Probe Construction: [**Gold-anodized, 6063 aluminum alloy tube**] [**or**] [**Type 316 stainless steel tube**], with each sensor probe containing one or more independently wired sensing nodes.

Transmitter:

Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.

User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:

Retain "Model GTC116 Transmitter" Subparagraph below for RS-485 (BACnet MS/TP or Modbus RTU) network connection applications.

Model GTC116 Transmitter: Two field-selectable [**0- to 5-V dc,**] [**0-to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

Retain "Model GTM116 Transmitter" Subparagraph below for Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection applications.

Model GTM116 Transmitter: Two field-selectable [**0- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

Retain "Model GTL116 Transmitter with LonWorks Free Topology Network Interface" Subparagraph below for LonWork applications.

Model GTL116 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

Retain "Model GTD116 Transmitter with Data-Logger Interface" Subparagraph below for data-logging applications.

Model GTD116 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

Retain "For Air-Ducted/Plenum - Duct Size 2 sq. ft. (0.18 sq. m) or Less" for smaller ducts or plenums when systems require either analog or network outputs.

For Air-Ducted/Plenum - Duct Size 2 sq. ft. (0.18 sq. m)or Less:

Airflow Station Performance:

Independent processing of up to four separately wired sensor-node assemblies.

Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

Sensor-Node and Probe Assemblies:

Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.

Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm (0 to 25.4 m/s).

Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

Provide the number of independent sensor nodes as follows:

For Duct/Plenum Area up to 0.5 sq. ft. (0.046 sq. m): One.

For Duct/Plenum Area Greater Than 0.5 through 1.0 sq. ft. (0.046 through 0.092 sq. m): Two.

For Duct/Plenum Area Greater Than 1.0 sq. ft. (0.092 sq. m): Four.

For probes less than 8 inches (203 mm), one sensor node/probe is required.)

Sensor-Probe Construction: [**Gold-anodized, 6063 aluminum alloy tube**] [**or**] [**Type 316 stainless steel tube**], with each sensor probe containing one or more independently wired sensing nodes.

Transmitter:

Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.

User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP, or Modbus RTU) field-selectable network connection.

Retain "Model HTA104 Transmitter, Analog Capability" or "Model HTAN104 Transmitter, Network Communications" Subparagraph below.

Model HTA104 Transmitter, Analog Capability: Two field-selectable [**0- 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm.

Model HTAN104 Transmitter, Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.

Retain "For Supply or Return Fan Array" Subparagraph below to measure individual flow and temperature of each fan in an array, and provide both analog and network outputs.

For Supply or Return Fan Array:

Airflow Station Performance:

Independent processing of up to eight separately wired sensor-node assemblies.

Accuracy: Within 10 percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

Sensor-Node and Probe Assemblies:

Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.

Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 10,000 fpm(0 to 50.8 m/s).

Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.

Number of Independent Sensor Nodes, Fan Arrays (One to Eight Fans): One probe with one sensor node per probe in each fan inlet.

Transmitter:

Transmitter determines the average airflow rate and temperature of each fan. Startup firmware facilitates the setup of multiple fans and fan areas.

User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:

Retain "Model GTC108 Transmitter" Subparagraph below for RS-485 (BACnet MS/TP or Modbus RTU) network connection applications.

Model GTC108 Transmitter: Two field-selectable [**0- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

Retain "Model GTM108 Transmitter" Subparagraph below for Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection applications.

Model GTM108 Transmitter: Two field-selectable [**0- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

Retain "Model GTL108 Transmitter with LonWorks Free Topology Network Interface" Subparagraph below for LonWorks Free Topology network connection applications.

Model GTL108 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

Retain "Model GTD108 Transmitter with Data-Logger Interface" Subparagraph below for data-logging applications.

Model GTD108 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

Retain first subparagraph below to measure flow and temperature on single- or double-width fans and to provide both analog and network outputs.

For Supply or Return Fan, Single-Width Single-Inlet (SWSI) or Double-Width Double-Inlet (DWDI) Fans - Both Analog and Network Outputs:

Airflow Station Performance:

Independent processing of up to eight separately wired sensor-node assemblies.

Accuracy: Within 10 percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

Sensor-Node and Probe Assemblies:

Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.

Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 10,000 fpm(0 to 50.8 m/s).

Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.

Number of Independent Sensor Nodes, SWSI Fans, and DWDI Fans: Two probes with one sensor node per probe in each fan inlet.

Transmitter:

Transmitter determines the average airflow rate and temperature of each fan. Startup firmware facilitates the setup of multiple fans and fan areas.

User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:

Retain "Model GTC108 Transmitter" Subparagraph below for the RS-485 (BACnet MS/TP Modbus RTU) network connection applications.

Model GTC108 Transmitter: Two field-selectable [**0- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

Retain "Model GTM108 Transmitter" Subparagraph below for Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection applications.

Model GTM108 Transmitter: Two field-selectable [**0- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, and overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

Retain "Model GTL108 Transmitter with LonWorks Free Topology Network Interface" Subparagraph below for LonWorks Free Topology network connection applications.

Model GTL108 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

Retain "Model GTD108 Transmitter with Data-Logger Interface" Subparagraph below for data-logging applications.

Model GTD108 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

Retain first subparagraph below to measure flow and temperature on single- or double-width fans and to provide either analog or network outputs.

For Supply or Return Fan, Single-Width Single-Inlet (SWSI) or Double-Width Double-Inlet (DWDI) Fans - Either Analog or Network Outputs:

Airflow Station Performance:

Independent processing of up to four separately wired sensor-node assemblies.

Accuracy: Within 10 percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

Sensor-Node and Probe Assemblies:

Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.

Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 10,000 fpm(0 to 50.8 m/s).

Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.

Number of Independent Sensor Nodes, SWSI Fans, and DWDI Fans: Two probes with one sensor node per probe in each fan inlet.

Transmitter:

Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.

User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.

Retain "Model HTA104 Transmitter, Analog Capability" or "Model HTN104 Transmitter, Network Communications" Subparagraph below for analog or network output.

Model HTA104 Transmitter, Analog Capability: Two field-selectable [**0- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm.

Model HTN104 Transmitter, Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.

Retain "For Air Terminal Units" Subparagraph below to measure flow and temperature in small ducts, 4- to 16-inch (102- to 406-mm) round diameter, for air terminal unit applications.

For Air Terminal Units:

Airflow Station Performance:

Independent processing of up to two separately wired sensor-node assemblies.

Accuracy: Within 3 percent of reading when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

Sensor-Node and Probe Assemblies:

Sensor-Node Calibration:

Individually calibrated at a minimum of seven calibration points to NIST-traceable volumetric standards from 0 to 3000 fpm (0 to 15.2 m/s).

Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

Provide the number of independent sensor nodes as follows:

For a Duct Diameter of 4 Inches (102 mm): One.

For Duct Diameters 5 through 16 Inches (127 through 406 mm): Two.

Sensor-Probe Construction: [**Mill-finish, 6063 aluminum alloy tube**] [**or**] [**Type 316 stainless steel tube**], with each sensor probe containing one or more independently wired sensing nodes.

Transmitter:

Transmitter determines the average airflow rate and temperature of all connected sensor nodes in an array for a single location.

User Interface: An alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.

Retain "Model EF-A Transmitter, Analog Capability" or "Model EF-N Transmitter, Network Communications" Subparagraph below for analog or network output.

Model EF-A Transmitter, Analog Capability: Two field-selectable [**0- 5-V dc,**] [**1- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**2- to 10-V dc,**] scalable analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm.

Model EF-N Transmitter, Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.

Contact Closure Relay: One dry contact relay with onboard jumper to drive a remote LED, rated for no less than 30 V dc or 24 V ac at 3 A maximum. User configurable as normally open or normally closed during set up.

Retain "For Packaged HVAC Units, 12.5 Tons (44.0 kW) or Smaller" Subparagraph below to measure flow and temperature when systems require either analog or network outputs.

For Packaged HVAC Units, 12.5 Tons (44.0 kW) or Smaller:

Airflow Station Performance:

Independent processing of up to two separately wired sensor-node assemblies.

Accuracy: Within 10 percent of reading when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

Sensor-Node and Probe Assemblies:

Sensor-Node Internal Wiring Connections: Sealed and protected from the elements and suitable for direct exposure to water. Devices with exposed leads are unacceptable.

Sensor-Node Calibration:

Individually calibrated at a minimum of seven calibration points to NIST-traceable airflow standards from 0 to 3000fpm (0 to 15.2 m/s).

Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

Provide the number of independent sensor nodes as follows:

For a Duct Diameter of 4 Inches (102 mm): One.

For Duct Diameters 5 through 16 Inches (127 through 406 mm): Two.

Sensor-Probe Construction: Mill-finish, 6063 aluminum alloy tube, with each sensor probe containing one or more independently wired sensing nodes.

Transmitter:

Transmitter determines the average airflow rate and temperature of all connected sensor nodes in an array for a single location.

User Interface: An alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.

Retain "Model EF-A Transmitter, Analog Capability" or "Model EF-N Transmitter, Network Communications" Subparagraph below for analog or network output.

Model EF-A Transmitter, Analog Capability: Two field-selectable [**0- to 5-V dc,**] [**1- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**2- to 10-V dc,**] scalable analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm.

Model EF-N Transmitter, Network Communications: RS-485 (BACnet MS/TP or Modbus RTU) network connection to provide average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.

Contact Closure Relay: One dry contact relay with onboard jumper to drive a remote LED, rated for no less than 30 V dc or 24 V ac at 3 A maximum. User configurable as normally open or normally closed during set up.

Retain "For Directional Airflow" Subparagraph below to detect small pressure differentials, as low as 0.0002 inch wg (0.05 Pa), between adjacent spaces.

For Directional Airflow:

Bi-directional airflow measurement station with temperature output and integral airflow alarming to determine the exfiltration or infiltration airflow rate, and its direction and temperature at each measurement location.

Bi-directional airflow, or equivalent differential pressure date, is provided to the BAS, with system status indication, configurable airflow alarm, and internal diagnostics routine.

Sensor-Node Calibration:

Individually calibrated at a minimum of nine calibration points to NIST-traceable volumetric standards from minus 3000 to plus 3000 fpm(minus 15.2 to plus 15.2 m/s).

Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

Probe to Transmitter Cables: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from minus 67 to plus 392 deg F(minus 55 to plus 200 deg C), and UV tolerant, with terminal plug for connection to the remotely mounted transmitter.

Transmitter:

Transmitter determines the average airflow rate and temperature of all connected sensor nodes in an array for a single location.

User Interface: An alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.

Retain "Model EF-A Transmitter, Analog Capability" or "Model EF-N Transmitter, Network Communications" Subparagraph below for analog or network output.

Model EF-A Transmitter, Analog Capability: Two field-selectable [**0- to 5-V dc,**] [**1- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**2- to 10-V dc,**] scalable and protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature low and/or high airflow set-point alarm (user-defined) or system status alarm.

Model EF-N Transmitter, Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.

Contact Closure Relay: One dry contact relay with onboard jumper to drive a remote LED, rated for no less than 30 V dc or 24 V ac at 3 A maximum. User configurable as normally open or normally closed during set up.

Retain "For Data Center Server Rack Airflow/Pressure and Temperature Monitor" Subparagraph below to detect small pressure differentials, as low as 0.0002 inch wg (0.05 Pa), and temperatures across containment zones.

For Data Center Server Rack Airflow/Pressure and Temperature Monitor:

[Manufacturers:](http://www.specagent.com/Lookup?ulid=13493) Subject to compliance with requirements, provide products by the following:

Dwyer Instruments

[Ebtron, Inc](http://www.specagent.com/Lookup?uid=123457123213).

ONICON Incorporated

Approved equivalent.

Bi-directional airflow measurement station with temperature output and integral airflow alarming to determine the exfiltration or infiltration airflow rate, and its direction and temperature at each measurement location.

Bi-directional airflow, or equivalent differential pressure data, is provided to the BAS, with system status indication, configurable airflow alarm, and internal diagnostics routines.

Sensor-Node and Probe Assemblies:

Sensor-Node Internal Wiring Connections: Sealed and protected from the elements and suitable for direct exposure to water. Devices with exposed leads are unacceptable.

Sensor Node Calibration:

Individually calibrated at a minimum of nine calibration points to NIST-traceable volumetric standards from minus 2000 to plus 2000 fpm(minus 10.2 to plus 10.2 m/s).

Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

Probe to Transmitter Cables: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from minus 67 to plus 392 deg F(minus 55 to plus 200 deg C), and UV tolerant, with terminal plug for connection to the remotely mounted transmitter. Plenum-rated PVC jacket cables are unacceptable.

Transmitter:

Integral Transmitter with Display: Mounted internally to the rack enclosure an integral, minimum 16-character LCD display capable of simultaneously displaying airflow and temperature, and capable of displaying individual airflow and temperature readings.

Transmitter Interface: Four-button interface for field configuration and diagnostics.

Isolation transformers are not be required with the power supply.

Power Supply: On-off power switch, 110 V ac at 8 VA, fused and protected from overvoltage, overcurrent, and power surges. Provide dual independent and redundant power supplies.

Network Interface: One isolated Ethernet network connection (simultaneously supporting field-selectable BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP protocols).

Retain "For Combination Control Damper and Airflow Station - Equal Area Method Distribution Pattern" Subparagraph below to measure flow and temperature through air intakes.

For Combination Control Damper and Airflow Station - Equal Area Method Distribution Pattern:

[Manufacturers:](http://www.specagent.com/Lookup?ulid=13494) Subject to compliance with requirements, provide products by the following or equal:

DWYER Instruments

[Ebtron, Inc](http://www.specagent.com/Lookup?uid=123457123214).

ONICON Incorporated

Approved equivalent.

Thermal airflow station and integral damper with two or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location. Sensor-node distribution pattern to be based on equal area method.

Airflow Station Performance:

Independent processing of up to 16 separately wired sensor-node assemblies.

Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

Sensor-Node and Probe Assemblies:

Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.

Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm (0 to 25.4 m/s).

Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

Provide the number of independent sensor nodes as follows:

For Damper Area up to 1.0 sq. ft. (0.092 sq. m): Two.

For Duct/Plenum Area Greater Than 1.0 through 4.0 sq. ft. (0.092 through 0.372 sq. m): Four.

For Duct/Plenum Area Greater Than 4.0 through 8.0 sq. ft. (0.372 through 0.743 sq. m): Six.

For Duct/Plenum Area Greater Than 8.0 through 12.0 sq. ft. (0.743 through 1.11 sq. m): Eight.

For Duct/Plenum Area Greater Than 12.0 through 16.0 sq. ft. (1.11 through 1.49 sq. m): 12.

For Duct/Plenum Area Greater Than 16.0 sq. ft. (1.49 sq. m): 16.

Sensor Probe Construction: Gold-anodized, 6063 aluminum alloy tube with each sensor probe containing one or more independently wired sensing nodes.

Transmitter:

Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.

User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:

Retain "Model GTC116 Transmitter" Subparagraph below for RS-485 (BACnet MS/TP Modbus RTU) network connection applications.

Model GTC116 Transmitter: Two field-selectable [**0- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

Retain "Model GTM116 Transmitter" Subparagraph below for Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection applications.

Model GTM116 Transmitter: Two field-selectable [**0- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, and overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

Retain "Model GTL116 Transmitter with LonWorks Free Topology Network Interface" Subparagraph below for LonWorks Free Topology network connection applications.

Model GTL116 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

Retain "Model GTD116 Transmitter with Data-Logger Interface" Subparagraph below for data-logging applications.

Model GTD116 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

Integral Control Damper and Sleeve:

Frame and Sleeve: Extruded 6063T5 aluminum with an integral damper frame.

Thickness: Not less than 0.080-inch (2.0-mm) thickness for each damper section.

Sleeve Depth: 15 inches (381 mm) for ducted applications and 18 inches (457 mm) for non-ducted applications including damper frame. Non-ducted applications include a 3-inch-(7.6-mm-) radius, aluminum entry flair.

Installation: Provide an additional 7 inches (178 mm) for non-ducted, 10 inches (254 mm) for ducted, applications between the downstream edge of an intake louver and the leading edge of the entry flair for outside air intake applications that are close coupled to intake louvers.

Leakage: The damper leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) of face area against 1-inch wg (248.8-Pa) differential static pressure.

Blades: Extruded 6063T5 aluminum airfoil blades not less than 0.060-inch (1.52-mm) thickness.

Blade Seals: Extruded EPDM.

Frame Seals: Extruded silicone secured in an integral slot within the aluminum extrusions.

Orientation: Parallel or opposed blade configuration as required by application.

Bearings: Celcon inner bearing fixed to a 7/16-inch (11.1-mm) aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.

Linkage: Aluminum- and corrosion-resistant zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip, installed inside the frame.

Control-Damper Actuator: Modulating, electronic, damper actuator of sufficient number and adequate size, factory mounted and tested. Control-damper actuators are specified in Section 230923.12 "Control Dampers."

Retain "For Combination Control Damper and Airflow Station - Modified Log Distribution Pattern" Subparagraph below to measure flow and temperature through air intakes.

For Combination Control Damper and Airflow Station - Modified Log Distribution Pattern:

[Manufacturers:](http://www.specagent.com/Lookup?ulid=13496) Subject to compliance with requirements, provide products by the following:

Dwyer Instruments

[Ebtron, Inc](http://www.specagent.com/Lookup?uid=123457123278).

ONICON Incorporated

Approved equivalent.

Thermal airflow station and integral damper with one or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location. Sensor node distribution pattern to be based on modified log Tchebycheff method.

Airflow Station Performance:

Independent processing of up to 16 separately wired sensor-node assemblies.

Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

Sensor-Node and Probe Assemblies:

Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.

Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm (0 to 25.4 m/s).

Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

Provide the number of independent sensor nodes as follows:

For Damper Area up to 1.0 sq. ft. (0.092 sq. m): Two.

For Duct/Plenum Area Greater Than 1.0 through 2.0 sq. ft. (0.092 through 0.185 sq. m): Four.

For Duct/Plenum Area Greater Than 2.0 through 4.0 sq. ft. (0.185 through 0.372 sq. m): Six.

For Duct/Plenum Area Greater Than 4.0 through 8.0 sq. ft. (0.372 through 0.743 sq. m): Eight.

For Duct/Plenum Area Greater Than 8.0 through 12.0 sq. ft. (0.743 through 1.11 sq. m): 12.

For Duct/Plenum Area Greater Than 12.0 through 14.0 sq. ft. (1.11 through 1.30 sq. m): 14.

For Duct/Plenum Area Greater Than 14.0 sq. ft. (1.49 sq. m): 16.

Sensor Probe Construction: Gold-anodized, 6063 aluminum alloy tube with each sensor probe containing one or more independently wired sensing nodes.

Transmitter:

Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.

User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:

Retain "Model GTC116 Transmitter" Subparagraph below for RS-485 (BACnet MS/TP Modbus RTU) network connection applications.

Model GTC116 Transmitter: Two field-selectable [**0- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

Retain "Model GTM116 Transmitter" Subparagraph below for Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection applications.

Model GTM116 Transmitter: Two field-selectable [**0- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, and overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

Retain "Model GTL116 Transmitter with LonWorks Free Topology Network Interface" Subparagraph below for LonWorks Free Topology network connection applications.

Model GTL116 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

Retain "Model GTD116 Transmitter with Data-Logger Interface" for data-logging applications.

Model GTD116 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

Integral Control Damper and Sleeve:

Frame and Sleeve: Extruded 6063T5 aluminum with an integral damper frame.

Thickness: Not less than 0.080-inch (2.0-mm) thickness for each damper section.

Sleeve Depth: 13 inches (330 mm) for all applications including damper frame. Sleeve includes a 1-inch-(2.56-mm-) radius, aluminum entry flair.

Installation: Provide an additional 7 inches (178 mm) between the downstream edge of an intake louver and the leading edge of the entry flair for outside air intake applications that are close coupled to intake louvers.

Leakage: The damper leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) of face area against 1-inch wg (248.8-Pa) differential static pressure.

Blades: Extruded 6063T5 aluminum airfoil blades not less than 0.060-inch (1.52-mm) thickness.

Blade Seals: Extruded EPDM.

Frame Seals: Extruded silicone secured in an integral slot within the aluminum extrusions.

Orientation: Parallel or opposed blade configuration as required by application.

Bearings: Celcon inner bearing fixed to a 7/16-inch (11.1-mm) aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.

Linkage: Aluminum- and corrosion-resistant zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip, installed inside the frame.

Control-Damper Actuator: Modulating, electronic, damper actuator of sufficient number and adequate size, factory mounted and tested. Control-damper actuators are specified in Section 230923.12 "Control Dampers."

Retain "For Combination Backdraft Damper and Airflow Station" Subparagraph below to measure flow and temperature through air intakes.

For Combination Backdraft Damper and Airflow Station:

[Manufacturers:](http://www.specagent.com/Lookup?ulid=13495) Subject to compliance with requirements, provide products by the following:

[Ebtron, Inc](http://www.specagent.com/Lookup?uid=123457123215).

Johnson Controls

Pottorff

Approved equivalent.

Thermal airflow station with one or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location.

Airflow Station Performance:

Independent processing of up to eight separately wired sensor-node assemblies.

Accuracy: Within 10 percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

Sensor-Node and Probe Assemblies:

Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.

Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 10,000 fpm (0 to 50.8 m/s).

Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.

Number of Independent Sensor Nodes, Fan Arrays (One to Eight Fans): One probe with one sensor node per probe in each fan inlet.

Transmitter:

Transmitter determines the average airflow rate and temperature of each fan. Startup firmware facilitates the setup of multiple fans and fan areas.

User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:

Retain "Model GTC108 Transmitter" Subparagraph below for RS-485 (BACnet MS/TP or Modbus RTU) network connection applications.

Model GTC108 Transmitter: Two field-selectable [**0- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

Retain "Model GTM108 Transmitter" Subparagraph below for Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection applications.

Model GTM108 Transmitter: Two field-selectable [**0- to 5-V dc,**] [**0- to 10-V dc,**] [**or**] [**4- to 20-mA,**] scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

Retain "Model GTL108 Transmitter with LonWorks Free Topology Network Interface" Subparagraph below for LonWorks Free Topology network connection applications.

Model GTL108 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

Retain "Model GTD108 Transmitter with Data-Logger Interface" Subparagraph below for data-logging applications.

Model GTD108 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

Integral Heavy-Duty Backdraft Damper:

Frame and Sleeve: Extruded 6063T5 aluminum with an integral damper frame.

Thickness and Depth: Not less than 0.080-inch (2.0-mm) thickness.

Sleeve Depth: 8 inches457 mm, which act as an integrated sleeve. Optional 1-inch-(7.6-mm-) radius, aluminum entry flair.

Installation: Provide an additional 7 inches (178 mm) between the downstream edge of any components and leading edge of the damper frame or entry flare.

Leakage: The damper leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) of face area against 1-inch wg (248.8-Pa) differential static pressure.

Blades: Extruded 6063T5 aluminum airfoil blades not less than 0.060-inch (1.52-mm) thickness.

Blade Seals: Extruded EPDM.

Frame Seals: Extruded silicone secured in an integral slot within the aluminum extrusions.

Orientation: Parallel configuration as required by application.

Bearings: Celcon inner bearing fixed to a 7/16-inch (11.1-mm) aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.

Linkage: Aluminum- and corrosion-resistant zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip, installed inside the frame.

* + - * 1. Pitot-Tube Airflow Sensor Station:

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

Air Monitor Corporation.

Johnson Controls

Ruskin Company.

Approved equivalent.

Requirements in remaining subparagraphs below are based on Air Monitor's "Fan Evaluator."

Description: Multiple total- and static-pressure sensors positioned at the center of equal area of the station cross section and interconnected by respective averaging manifolds.

Stations 4 sq. ft. (0.4 sq. m) and Smaller: One total-pressure sensor and one static-pressure sensor for every 16 sq. in. (103 sq. cm) of station area.

Stations Larger than 4 sq. ft. (0.4 sq. m): One total-pressure sensor and one static-pressure sensor for every 36 sq. in. (232 sq. cm) of station area.

Casing: Galvanized sheet steel at least 0.079 inch (2.0 mm) thick with coating complying with ASTM A653/A653M, G90 (Z275). Casings shall be stainless steel, 0.0781 inch (2.0 mm) thick, when connected to stainless duct and aluminum, 0.063 inch (1.6 mm) thick, when connected to aluminum duct.

Joints and Seams: Continuously weld. Clean galvanized areas damaged by welding and coat with aluminum paint.

Casing Depth: At least 8 inches (200 mm).

Casing Flanges: Outward flange, minimum flange face 1.5 inches (38 mm).

Casing Configuration and Size: Match shape (rectangular, round, flat oval) and same size as adjacent duct unless otherwise indicated.

Include an open parallel cell air straightener or air equalizer honeycomb mechanically fastened to casing.

Construct straightener or equalizer from Type 3003 aluminum or Type 316 stainless steel, depending on casing material. Use stainless steel for units with stainless-steel casings.

Construct pressure sensor array from drawn copper or stainless-steel tubing. Use stainless steel for units with stainless-steel casings. Copper tubing shall comply with ASTM B75 and ASTM B280. Minimum tube wall thickness shall be 0.030 inch (0.8 mm). Include internal piping and external pressure transmitter ports.

Station Labeling: Identification label on each station casing indicating model number, size, area, and application-specific airflow range.

Performance:

Pressure Loss: 0.015-inch wg (3.8 Pa) at 1000 fpm (5 m/s), or 0.085-inch wg (22.5 Pa) at 2000 fpm (10 m/s).

Accuracy: Within 2 percent of actual airflow.

Self-Generated Sound: NC 40 and sound level within the duct shall not be amplified.

Performance rated and tested according to AMCA 610. Each station shall bear the AMCA seal.

Delete "Pitot-Tube Fan Inlet Airflow Traverse Sensor" Paragraph below if fans with airflow measurement integral to fan inlet cones for continuously measurement of air volume flow rate are specified in fan specifications.

* + - * 1. Pitot-Tube Fan Inlet Airflow Traverse Sensor:

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

Air Monitor Corporation

Johnson Controls

Ruskin Company

Approved equivalent

Requirements in remaining subparagraphs below are based on Air Monitor's "Volu-probe/FI or FI/SS."

Traverse manifold designed for mounting in fan inlets.

Contain multiple total- and static-pressure sensors placed at concentric area centers along the exterior surface of cylindrical manifold and internally connected to their respective averaging manifolds. Sensors shall not protrude beyond the surface of the manifold nor be adversely affected by particle contamination present in airstream.

Manifold (two per inlet) shall have dual end support swivel brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings.

Sensors shall be capable of producing steady, non-pulsating signals of standard total- and static-pressure without need for flow corrections or factors, with an accuracy of 3 percent of actual flow over a turndown range of 6 to 1.

Manifold Materials: [**Copper or anodized aluminum**] [**or**] [**Type 316 stainless steel**].

Unless otherwise required by application and without affecting the fan and sensor performance, nominal diameter copper and aluminum manifolds shall be the following:

For Fan Inlets Smaller Than 20 Inches (500 mm): 0.375 inch (9 mm).

For Fan Inlets 20 Inches (500 mm) and Larger: 0.75 inch (19 mm).

Unless otherwise required by application and without affecting the fan and sensor performance, nominal diameter stainless steel manifolds shall be the following:

For Fan Inlets Smaller Than 20 Inches (500 mm): 0.375 inch (9 mm).

For Fan Inlets 20 through 48 Inches (500 through 1200 mm): 0.75 inch (19 mm).

For Fan Inlets Larger Than 48 Inches (1200 mm): 1.0 inch (25 mm).

"Piezometer Ring Fan Inlet Airflow Sensor" Paragraph below is an alternative to externally mounted fan inlet airflow sensors. Coordinate with fan specifications. These airflow sensors can be provided by some fan manufacturers as a component of the fan.

* + - * 1. Piezometer Ring Fan Inlet Airflow Sensor:

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

EBM-Papst, Inc.

Johnson Controls

Twin City Fan & Blower.

Approved equivalent.

Requirements in remaining subparagraphs below are based on Twin City Fan's "Piezometer Ring."

In lieu of externally mounted fan inlet airflow sensors, option to provide fans with airflow measurement integral to fan inlet cones for continuous measurement of air volume flow rate.

Multiple pressure sensor points strategically placed along the circumference of the inlet cone and internally connected to an averaging ring manifold located behind the inlet cone.

Sensor points shall not protrude beyond the surface of the inlet cone nor be adversely affected by particle contamination present in the airstream.

Sensor shall produce steady, non-pulsating signals to achieve accuracy within 5 percent of actual airflow.

Sensor shall be non-intrusive and not impact fan performance.

Product shall be a standard offering of the fan manufacturer and include published literature with supporting test data to validate sensor performance.

* + - 1. AIRFLOW SWITCHES
				1. Polymer Film Sail Switch:

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

Honeywell International Inc.

L.B. White Company

McMaster-Carr

Approved equivalent.

Requirements in remaining subparagraphs below are based on Honeywell's "Model S688A."

Performance:

Suitable for applications operating at velocities up to 400 fpm (2.0 m/s).

Suitable for mounting with air direction in horizontal, vertical up or down.

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

Voltage: 24-, 120-, 240-V ac.

Normally Open Full Load Current: 2 A at 120-V ac.

Normally Closed Full Load Current: 1 A at 120-V ac.

Normally open switch actuates at 250 fpm (1.3 m/s) and opens at 75 fpm (0.4 m/s).

Normally closed switch actuates at 75 fpm (0.4 m/s) and closes at 250 fpm (1.3 m/s).

Maximum Process Temperature: 170 deg F (77 deg C).

Maximum Ambient Temperature: 125 deg F (52 deg C).

Construction:

Polyester film sail encasing a wire frame.

Sail actuates a SPDT snap switch.

Enclosure Material: Zinc-plated steel.

Enclosure with removable cover.

NEMA 250, Type 1 enclosure.

Removable spring counterbalances sail to allow mounting in either vertical (up or down) or horizontal airflow.

Electrical Connections: Screw terminals.

Conduit Connections: 1/2-inch (16-mm) trade size conduit knock outs on top and bottom.

* + - * 1. Stainless Steel Single Vane Switch:

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

Dwyer Instruments, Inc.

Johnson Controls

W.E. Anderson

Approved equivalent.

Requirements in remaining subparagraphs below are based on Dwyer’s “Model 530.”

Description:

Velocities up to 2000 fpm (10.2 m/s).

Suitable for mounting with air direction in horizontal.

Performance:

Voltage: 125-, 240-, and 480-V ac.

Full Load Current: 9.8 A at 125-V ac.

Field-Adjustable Velocity Set Point: 400 to 1600 fpm (2.0 to 8.2 m/s).

Maximum Process Temperature: 180 deg F (82 deg C).

Maximum Ambient Temperature: 125 deg F (52 deg C).

Construction:

Stainless steel vane.

Vane actuates a SPDT snap switch.

Enclosure Material: Die-cast metal.

Enclosure with removable cover.

NEMA 250, Type 1 enclosure.

Screw set-point adjustment.

Electrical Connections: Screw terminals.

Conduit Connections: 1-inch (27-mm) trade size conduit knock outs on top and bottom.

* + - 1. AIRFLOW TRANSMITTERS
				1. Airflow Transmitter with 0.10 Percent Accuracy and Auto-Zero Feature:

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

Air Monitor Corporation.

Dwyer Instruments.

Paragon Controls Incorporated

Approved equivalent.

Requirements in remaining subparagraphs are based on Air Monitor's "Veltron II."

Transmitter shall receive total- and static-pressure signals from a primary element, amplify signals, extract the square root, and scale the signals to produce 4- to 20-mA dc output signals linear to airflow.

NEMA 250, Type 1 enclosure.

Construct assembly so that shock, vibration, and pressures surges of up to 1 psig (6.9 kPa) will neither harm transmitter, nor affect its accuracy.

Transmitter with automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. The automatic zeroing circuit shall re-zero transmitter to within 0.1 percent of true zero.

Performance:

Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.

Calibrated Span: Field adjustable, minus 40 percent of the range.

Accuracy: Within 0.10 percent of natural span.

Repeatability: Within 0.15 percent of calibrated span.

Linearity: Within 0.2 percent of calibrated span.

Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.

Integral digital LED or digital display for continuous indication of airflow.

* + - * 1. Airflow Transmitters with 0.25 Percent Accuracy and Auto-Zero Feature:

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

Air Monitor Corporation.

Dwyer Instruments

Paragon Controls Incorporated

Approved equivalent.

Requirements in remaining subparagraphs below are based on Air Monitor's "DPT 2500 Plus."

Transmitter shall receive total- and static-pressure signals from a flow element, amplify signals, extract the square foot, and scale the signals to produce 4- to 20-mA dc output signals linear to airflow.

NEMA 250, Type 1 enclosure.

Construct assembly so shock, vibration, and pressures surges of up to 1 psig (6.9 kPa) will neither harm transmitter, nor affect its accuracy.

Transmitter with automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. The automatic zeroing circuit shall re-zero the transmitter to within 0.1 percent of true zero.

Performance:

Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.

Calibrated Span: Field adjustable, minus 40 percent of the range.

Accuracy: Within 0.25 percent of natural span.

Repeatability: Within 0.15 percent of calibrated span.

Linearity: Within 0.2 percent of calibrated span.

Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.

Integral digital display for continuous indication of airflow.

* + - * 1. Pressure Differential Transmitters for Airflow Measurement:

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

Dwyer Instruments

Setra System.

Paragon Controls Incorporated

Approved equivalent.

Requirements in remaining subparagraphs below are based on Setra'’s "“Model 267."”

Performance:

Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.

Accuracy: Within [**1**] [**0.5**] [**0.4**] [**0.25**] percent of the full-scale range.

Hysteresis: Within 0.10 percent of full scale.

Repeatability: Within 0.05 percent of full scale.

Stability: Within one percent of span per year.

Overpressure: 10 psig (69 kPa).

Temperature Limits: Zero to 150 deg F (Minus 18 to plus 66 deg C).

Compensate Temperature Limits: 40 to 150 deg F (4 to 66 deg C).

Thermal Effects: 0.033 percent of full scale per degree F.

Shock and vibration shall not harm the transmitter.

Output Signals:

Retain "“Analog Current Signal"” or "“Analog Voltage Signal"” subparagraphs below to restrict signal options.

Analog Current Signal:

Two-wire, 4- to 20-mA dc current source.

Signal capable of operating into 800-ohm load.

Analog Voltage Signal:

Three wire, zero to [**5**] [**10**] V.

Minimum Load Resistance: 1000 ohms.

Retain "“Display"” Subparagraph below for optional display.

Display: Four-digit digital with minimum 0.4-inch- (10-mm-) high numeric characters.

Operator Interface:

Zero and span adjustments located behind cover.

Construction:

Plastic casing with removable plastic cover.

Fittings: Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.

Screw terminal block for wire connections.

Vertical plane mounting.

NEMA 250, Type 4.

Mounting Bracket: Appropriate for installation.

* + - * 1. Pressure Differential Indicating Transmitter, Switch, and Controller for Airflow Measurement:

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

Ashcroft

Dwyer Instruments, Inc.

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining subparagraphs below are based on Dwyer Instruments’ “Series DH3 Digihelic.”

Description:

Three-in-one instrument, including digital display, control relay switches, and a transmitter with a current output.

Field configurable for pressure, velocity, and volumetric flow applications through user interface.

Select instrument range based on application.

Performance:

Accuracy including hysteresis and repeatability:

Ranges Less than 5-Inch wg (1250 Pa): Within 1 percent.

Other Ranges: Within 0.5 percent at 77 deg F (25 deg C).

Stability: Within 1 percent per year.

Response Time: 250 ms.

Overpressure:

Ranges Less than 50-Inch wg (12.5 kPa): 5 psi (34.5 kPa).

Range of 100-Inch wg (25 kPa): 9 psi (62 kPa).

Temperature Limits: 32 to 140 deg F (Zero to 60 deg C).

Thermal Effects: 0.020 percent per deg F (deg C).

Warm-up Period: One hour.

Controller: Programming through menu keys to access five menus.

Security level.

Pressure, velocity, or flow application.

Engineering units.

K-factor for use with flow application.

Set-point control only; set-point and alarm operation; alarm operation as high, low, or high/low with manual; or automatic reset and delay.

View high and low readings.

Digital dampening for smoothing erratic applications.

Scaling of analog output to fit range and field calibration.

Display:

Four-digit digital, with minimum 0.4-inch- (10-mm-) high alphanumeric characters.

Four LED indicators; two LEDs for set point and two LEDs for alarm status.

Operator Interface:

Set-point adjustment through keypad on face of instrument.

Zero and span adjustments accessible through menu.

Programming through keypad.

Output Analog Signal: Two-wire, 4- to 20-mA dc current source; capable of operating into a 900-ohm load.

Output Digital Signal: Two, SPDT relays; each rated for 1 A at 30-V ac or 30-V dc.

Construction:

Die-cast aluminum casing and bezel.

Connections on side and back.

Vertical plane mounting.

NEMA 250, Type 1 rating.

Nominal 4-inch- (100-mm-) diameter face.

Mounting Bracket: Appropriate for installation.

* + - 1. LIQUID FLOW METERS
				1. General Requirements for Liquid Flow Meters:

Adjustable for changes in system operational parameters.

Liquid and Steam Sensors, Meters, and Transmitters: Extended range of [**10**] [**20**] <**Insert number**> percent above Project design flow and [**10**] [**20**] <**Insert number**> percent below Project minimum flow to signal abnormal flow conditions.

Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.

Product certificates are required.

* + - * 1. Insertion Paddle Wheel Flow Meter, NPS 2 (DN 50):

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

Badger Meter, Inc.

Data Industrial

Veris Industries.

Approved equivalent.

Requirements in remaining subparagraphs below are based on Data Industrial's "Series 200 Sensor with Series 500 Transmitter."

Description: Insertion-type meter with a non-magnetic spinning paddle wheel.

Performance:

Range: 0.5 to 30 fps (0.15 to 9.1 mps).

Accuracy: Within 1 percent of full scale over flow range.

Linearity: Within 0.2 percent of full scale over flow range.

Repeatability: Within 0.3 percent of full scale over flow range.

Ambient Temperature: 14 to 150 deg F (Minus 10 to plus 66 deg C).

Maximum Process Temperature: [**221 deg F (105 deg C)**] [**285 deg F (141 deg C)**].

Maximum Pressure: 400 psig at 100 deg F (2758 kPa at 38 deg C).

Output Signal: Frequency pulse.

Construction:

Wetted Metal Parts, Including Sensor Sleeve, Mounting Adapter, and Isolation Valve: [**Brass**] [**Type 316 stainless steel**].

Shaft: [**Tungsten carbide**] [**Titanium**] [**Hastalloy C**] [**Monel**] [**Type 316 stainless steel**].

Impeller: [**Nylon**] [**Tefzel**].

Process Connection: NPS 2 (DN 50).

Instrument Isolation Valve: [**Gate**] [**Full port ball**] valve for system isolation.

Insertion Depth: Threaded positioning nut for accurate sensor depth in the pipe.

Electronics Enclosure:

Polyphenylene sulfide (PPS) with Viton seal.

Electrical Connection: Cable furnished with sensor.

Transmitter:

User-adjustable scale to refine resolution of flow range over 4- to 20-mA signal.

Enclosure Material: Polycarbonate with tongue and groove, with neoprene sealed cover.

NEMA 250, Type 4X enclosure.

Electrical Connection: Screw terminals.

Linearity less than one percent.

Output Response Time: 6 seconds for 10 to 90 percent step.

Load resistance of 650 ohms at 24-V dc.

Operating Temperature: Minus 32 to plus 122 deg F (Minus 36 to plus 50 deg C).

Retain subparagraph below for digital display.

Digital display of flow rate.

* + - * 1. Insertion Paddle Wheel Flow Meter, NPS 1 (DN 25):

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

Badger Meter, Inc.

Data Industrial

Omega Engineering

Approved equivalent.

Requirements in remaining subparagraphs below are based on Data Industrial's "SDI Series."

Description:

Insertion-type meter with a non-magnetic spinning paddle wheel.

Retain first subparagraph below for wet calibration. Better accuracy is available with wet calibration.

Each meter shall be wet calibrated at factory to standards traceable to NIST and provided with a certificate of calibration.

Programming kit including cable connector and Microsoft-Windows-compatible software.

Where indicated, provide meter with bi-directional flow measurement.

Performance:

Range: 0.33 to 20 fps (0.1 to 6.1 m/s).

Standard accuracy is 1 percent. 0.5 percent accuracy requires wet calibration.

Accuracy: Within [**0.5**] [**1**] percent of flow rate.

Repeatability: Within 0.5 percent.

Ambient Temperature: 14 to 150 deg F (Minus 10 to plus 66 deg C).

Maximum Process Temperature: 300 deg F (149 deg C) with PEEK sensor tip.

Maximum Pressure: 350 psig at 300 deg F (2413 kPa at 149 deg C) with PEEK sensor tip.

Pressure Drop: Up to 0.5 psig at 10 fps (3.5 kPa at 3 m/s) for pipe sizes NPS 1-1/2 (DN 20) and larger.

Output Signal:

Retain one of three "Unidirectional Flow Meter" subparagraphs below.

Unidirectional Flow Meter: Frequency pulse.

Unidirectional Flow Meter: Analog, two wire, loop-powered, 4- to 20-mA signal.

Unidirectional Flow Meter: Scaled pulse.

Retain one of two "Bi-directional Flow Meter" subparagraphs below. Only available with PPS tip.

Bi-directional Flow Meter: Analog 4- to 20-mA signal plus direction.

Bi-directional Flow Meter: Scaled pulse.

Operator Interface:

Programming: Instrument programming through computer and programming kit.

Retain "Digital Display" Subparagraph below for optional digital display. Optional digital display is not available with frequency pulse output signal.

Digital Display: Eight-character digital display of flow rate, flow totalization, input, output, and flow direction for bi-directional meters.

Construction:

Wetted Metal Parts (Including Sensor Stem, Mounting Adapter, and Isolation Valve): Type 316 stainless steel.

Sensor Tip: PPS or PEEK.

Shaft: Tungsten carbide.

Impeller: Stainless steel.

Process Connection: NPS 1 (DN 25).

Instrument Isolation Valve: Full port ball valve for system isolation.

Insertion Depth: Threaded positioning nut for accurate sensor depth in the pipe.

Electronics Enclosure:

Polypropylene with Viton-sealed acrylic cover.

Removable cover.

NEMA 250, Type 4X.

Electrical Connection: Screw terminals.

Conduit Connection: 1/2-inch (16-mm) trade size.

* + - * 1. Insertion Turbine Flow Meter:

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

Hoffer Flow Control

ONICON Incorporated

Spirax Sarco Limited.

Approved equivalent.

Requirements in remaining subparagraphs below are based on Onicon’s “F-1100 Series Sensor with D-1200 Series Remote Display Module” for pipe sizes NPS 1-1/4 to NPS 2 (DN 32 to DN 50), “Onicon F-1200 Series Sensor with D-1200 Series Remote Display Module” for pipe sizes NPS 2-1/2 (DN 65) and larger.

Description:

Operating pressure of 300 psig (2068 kPa) with a temperature of 200 deg F (93 deg C).

Meters in hot water systems shall be suitable for maximum system temperatures encountered, but not less than 250 deg F (121 deg C).

Pressure drop not to exceed 1 psig (6.9 kPa) at 20-fps (6.1-m/s) flow velocity in a NPS 2 (DN 50) pipe and decreasing in large pipe with lower velocity.

Sensor Accuracy:

Within 1 percent of actual flow between the flow velocity range of 3 to 30 fps (0.9 to 9.1 m/s).

Within 2 percent of actual flow between the flow velocity range of 0.4 to 20 fps (0.1 to 6.1 m/s).

Within 0.5 percent of actual reading at the calibrated velocity.

Wet calibrate and tag sensors to standards traceable to NIST, and provide each sensor with a certificate of calibration.

Sensor:

For Pipe Sizes NPS 2 (DN 50) and Smaller: Single turbine sensors.

For Pipe Sizes NPS 2-1/2 (DN 65) and Larger: Dual turbine sensors.

Piping with Bi-directional Flow: Bi-directional dual turbine sensors.

Dual turbine sensors shall have dual, contra-rotating turbine elements, each turbine element with its own rotational sensing system, and an averaging circuit.

Rotational sensing of each turbine shall be accomplished electronically by sensing electronic impedance change (non-magnetic and non-photoelectric).

Sensor shall have an integral frequency output linear with flow rate. For dual turbine units, with individual top and bottom turbine outputs for diagnostic purposes.

Bi-directional sensors shall have isolated solid-state dry contacts with a contact rating of 100 mA at 50 V. The contacts shall close when the flow in direction of arrow is 0.18 fps (0.05 m/s) or more.

Flow sensor shall be complete with installation hardware necessary to enable insertion and removal from pipe without system shutdown.

Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts. Construct wetted metal components of Type 316 stainless steel, including installation hardware.

House sensor electronics in a NEMA 250, Type 4 enclosure.

Enclosure shall include connection(s) for field-installed conduit.

Sensor shall have cable of length sufficient to connect to display module.

Sensor housing shall have full port [**Type 316 stainless steel**]ball valve for system isolation.

Display Module:

Remote from sensor.

House in a NEMA 250, Type 4X enclosure.

Label terminal strip for all wiring connections.

120-V ac power supply with 24-V dc output to power the flow sensor.

Remote Interface:

Retain “Hardwired Analog Outputs for Flow Rate and Totalization” or “Serial Communication Interface” Subparagraph below.

Hardwired Analog Outputs for Flow Rate and Totalization: 4 to 20 mA and zero- to 10-V dc.

Serial Communication Interface: Compatible with host to share flow rate and totalized flow data.

Outputs linear to within 0.1 percent of calibrated span.

Digital display for flow rate and totalized flow.

At least eight display digits for totalization.

Bi-directional units with separate digital display for flow and totalization in each direction.

Local reset of flow totalization.

Program and data shall be stored in nonvolatile memory in event of power loss.

For bi-directional units, with display of flow direction (contacts open or closed).

* + - * 1. Inline Turbine Flow Meter:

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

Badger Meter

Omega Engineering

ONICON Incorporated.

Approved equivalent.

Requirements in remaining subparagraphs below are based on Onicon's "F-1300 Series Sensor with D-1200 Series Remote Display Module."

Description:

Available in NPS 3/4 and NPS 1 (DN 20 and DN 25).

Operating pressure of 300 psig (2068 kPa) with a temperature of 200 deg F (93 deg C).

Meters in hot water systems shall be suitable for maximum system temperatures encountered, but not less than 250 deg F (121 deg C).

Pressure drop not to exceed 3 psig at 38 gpm (21 kPa at 2.4 L/s).

Sensor Accuracy:

Within 2 percent of actual flow between the flow range of 0.8 to 38 gpm (0.05 to 2.4 L/s).

Within 0.5 percent of actual reading at the calibrated velocity.

Wet calibrate and tag sensors to standards traceable to NIST, and provide each sensor with a certificate of calibration.

Sensor:

Rotational sensing of turbine shall be accomplished electronically by sensing electronic impedance change (non-magnetic and non-photoelectric).

Sensor shall have an integral frequency output linear with flow rate.

Sensor shall have threaded union on each end.

Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts.

Construct wetted metal components of brass or stainless steel.

House sensor electronics in a NEMA 250, Type 4 enclosure.

Enclosure shall include connection(s) for field-installed conduit.

Sensor shall have cable of length sufficient to connect to display module.

Display Module:

Remote from sensor.

Enclosure: NEMA 250, Type 4X.

Label terminal strip for all wiring connections.

120-V ac power supply with 24-V dc output to power the flow sensor.

Remote Interface:

Retain "Hardwired Analog Outputs for Flow Rate and Totalization" or "Serial Communication Interface" Subparagraph below.

Hardwired Analog Outputs for Flow Rate and Totalization: 4 to 20 mA and zero- to 10-V dc.

Serial Communication Interface: Compatible with host to share flow rate and totalized flow data.

Outputs linear to within 0.1 percent of calibrated span.

Digital display of flow rate and totalized flow.

At least eight display digits for totalization.

Local reset of flow totalization.

Program and data shall be stored in nonvolatile memory in the event of power loss.

* + - * 1. In-line Body Electromagnetic Flow Meter:

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

OMEGA Engineering

ONICON Incorporated

Spirax Sarco Limited.

Approved equivalent.

Requirements in remaining subparagraphs below are based on Onicon’s “F-3200 Series.”

Description:

No moving parts.

Suitable for flow measurement of fluids with electrical conductivity more than 5 micro-Seimens per cm.

Inherent bi-directional flow measurement.

Flow measurement with three pipe diameters upstream and two pipe diameters downstream.

Wet calibrate and tag meters to standards traceable to NIST, and provide each meter with a certificate of calibration.

Transmitter [**integral to**] [**remote from**] meter.

Performance:

Accuracy for Velocities between 3.3 and 33 fps (1 and 10 m/s): Within 0.2 percent of reading.

Accuracy for Velocities between 1.0 and 3.3 fps (0.3 and 1 m/s): Within 0.75 percent of reading.

Accuracy for Velocities Less than 1.0 fps (0.3 m/s): Within 0.0075 fps (0.0023 m/s).

Ambient Temperature: Minus 4 to plus 140 deg F (Minus 20 to plus 60 deg C).

Process Temperature: Minus 4 to 212 deg F (Minus 20 to plus 100 deg C).

Pressure: [**225 psig (1551 kPa)**] [**580 psig (3999 kPa)**].

Analog Output Current Signal:

Two-wire, 4- to 20-mA dc current source.

Signal capable of operating into 1000-ohm load.

Isolated.

Digital Output Signal: Two, programmable, digital/pulse outputs configurable for frequency, pulse, or directional flow.

Operator Interface:

Keypad.

Digital Display: Multiple-line digital display of alphanumerical characters.

LED for normal and alarm operation.

Construction:

Body: [**Epoxy-coated carbon steel**] [**Type 316 stainless steel**].

PTFE liner offers greater size and temperature range. Consult manufacturer for liner limitations.

Body Liner Material: [**PTFE**] [**Ebonite**] [**Polypropylene**].

Flow Tube: Type 304 stainless steel.

Connection: [**150 Class flange**] [**300 Class flange**] [**Threaded**] [**Wafer**].

Electrodes: Type 316 stainless steel. Quantity determined by manufacturer based on application.

Electronics Enclosure:

Painted aluminum.

Removable cover.

NEMA 250, Type 6.

* + - * 1. Insertion Electromagnetic Flow Meter:

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

ABB Automation Company

OMEGA Engineering

ONICON Incorporated.

Approved equivalent.

Requirements in remaining subparagraphs below are based on Onicon's "F-3500 Series" (with or without "D/B-1200 Series remote display module").

Description:

No moving parts.

Suitable for flow measurement of fluids with electrical conductivity between 20 to 60000 micro-Seimens per centimeter.

Suitable for pipe sizes NPS 3 through NPS 72 (DN 80 through DN 1800).

Wet calibrate and tag meters to standards traceable to NIST, and provide each meter with a certificate of calibration.

Continuous auto-zero function.

Transmitter integral to meter.

Performance:

Flow Range: 0.25 to 20 fps (0.08 to 6.1 m/s).

Accuracy for Velocities between 2 and 20 fps (0.6 to 6.1 m/s): Within 1 percent of reading.

Accuracy for Velocities Less than 2 fps (0.6 m/s): Within 0.02 fps (0.006 m/s).

Ambient Temperature: Minus 5 to 150 deg F (Minus 21 to plus 66 deg C).

Process Temperature: 15 to 250 deg F (Minus 9 to plus 121 deg C).

Pressure: 400 psig (2758 kPa).

Output Signals:

Field-selectable analog signals.

Current Signal (Isolated): 4 to 20 mA.

Voltage Signal (Isolated): Zero- to [**5**] [**10**]-V dc.

Digital Signal: Dry-contact closure signaling fault condition.

Frequency Signal: Zero- to 15-V peak pulse, zero to 500 Hz.

Scalable Pulse Output:

Isolated solid-state dry contact.

Contact Rating: 100 mA at 50-V dc.

Pulse Duration: 0.5, 1, 2, or 6 seconds.

Construction:

Wetted Metal Parts: Type 316 stainless steel.

Sensor Head: Polysulfone.

Process Connection: 1-inch (25-mm).

Instrument Isolation Valve: Full port Type 316 stainless steel ball valve for system isolation.

Electrodes: Type 316 stainless steel.

Electronics Enclosure:

Painted aluminum.

Removable cover.

NEMA 250, Type 4.

Electrical Connection: PVC-jacketed cable, 10 feet (3 m) long.

Conduit Connection:1/2-inch (16 mm) trade size.

Retain "Display Module" Subparagraph below to require meter with display.

Display Module:

Remote from meter.

House in a NEMA 250, Type 4X enclosure.

Label terminal strip for all wiring connections.

120-V ac power supply with 24-V dc output to power the flow sensor.

Input Signal from Meter: Zero- to 15-V pulse output.

Output Signals: Additional output signals furnished with flow meter connected to display module terminal strip.

Retain one of three "Auxiliary Output Signals" subparagraphs below.

Auxiliary Output Signals: Analog current output (isolated) shall be 4 to 20 mA.

Auxiliary Output Signals: Analog voltage output (isolated) shall be zero to [**5**] [**10**] V.

Auxiliary Output Signals: Digital output (isolated) shall be solid-state dry contacts rated for 100 mA at 50 V.

Digital Display:

Flow rate.

Totalized flow.

At least six display digits for flow rate and eight display digits for totalization.

Bi-directional units with separate digital display for flow and totalization in each direction.

Local reset of flow totalization.

Program and data shall be stored in nonvolatile memory in the event of power loss.

For bi-directional units, provide LED display of flow direction (contacts open or closed).

* + - * 1. Vortex Shedding Flow Meter with Integral Temperature Measurement:

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

OMEGA Engineering

ONICON Incorporated.

Spirax Sarco Limited.

Approved equivalent.

Requirements in remaining subparagraphs below are based on Onicon's "F-2200 Series" (with or without "D-2100 Series remote display").

Description:

Flow measurement using vortex shedder body with integral 1000-ohm platinum RTD.

Meter NPS 3/8 through NPS 8 (DN 10 through DN 200).

Each meter shall be factory calibrated at five points from zero to 250 fps (zero to 76 m/s) and tagged accordingly against the manufacturer's flow standards. The manufacturer shall provide a certificate of calibration for meter.

Each meter shall be programmed using project-specific application data.

Meter shall include integral diagnostics to verify installation conditions and proper operation.

Performance:

Volumetric Flow Accuracy: Within 1 percent of reading for meter NPS 1 (DN 25) and larger; within 2 percent of reading for smaller sizes.

Mass Flow Accuracy: Within 1.5 percent of reading for NPS 1 (DN 25) and larger; within 2.5 percent of reading for smaller sizes.

Ambient Temperature: Zero to 132 deg F (Minus 18 to plus 56 deg C).

Process Temperature: 25 to 464 deg F (Minus 4 to plus 240 deg C).

Pressure: Equal to flange rating.

Output Signals:

Analog Current Signal of Flow Rate:

Two-wire, 4- to 20-mA dc current source.

Signal capable of operating into 1000-ohm load.

Digital Signal: Pulse output for flow totalization. Two wire, scaled pulse, 0.5 Hz, 100 mA at 30-V dc.

Operator Interface:

Keypad.

Digital Display: Two-line digital display of alphanumerical characters. The meter shall display flow rate, flow totalization, and temperature and support field programming of all parameters.

Construction:

Material: Type 316L stainless steel for sizes through NPS 4 (DN 100); Type 304 stainless steel for larger sizes.

Connection: [**Class 300**] [**Class 600**] flange.

Vortex Shedder: Unalloyed titanium.

Shedder Seal: Nickel-plated Inconel.

Enclosure:

Epoxy-painted cast aluminum.

Removable screw-on cover.

NEMA 250, Type 4X.

Electrical Connection: Screw terminals.

Conduit Connection: Two, 1/2-inch (16-mm) trade size.

Retain "Remote Display Module" Subparagraph to require meter with remote display.

Remote Display Module:

Remote from meter.

House in a NEMA 250, Type 4 enclosure.

Label terminal strip for all wiring connections.

120-V ac power supply with 24-V dc output to power the flow meter.

Input Signal from Meter: Analog current, 4 to 20 mA.

Output Signals:

Analog Current Output: Two wire, 4 to 20 mA, maximum loop resistance 275 ohms.

Digital Output (Isolated): Solid-state dry contacts rated for 100 mA at 50-V dc.

Digital Display:

Flow rate.

Totalized flow.

Display Digits: 3.5 for flow rate and 8 for totalization.

Local reset of flow totalization.

Program and data shall be stored in nonvolatile memory in the event of power loss.

Upstream Flow Straightener:

Flow straightener where required by installation.

Straightener shall be wafer type, constructed of Type 304 stainless steel, designed to be installed between field-installed flanges.

Straightener size shall match meter size.

* + - * 1. Vortex Shedding Flow Meter with Integral Pressure and Temperature Measurement:

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

Honeywell International

OMEGA Engineering

ONICON Incorporated.

Approved equivalent.

Requirements in remaining subparagraphs below are based on Onicon's "F-2500 Series."

Description:

Mass flow measurement corrected for density using vortex shedder body with integral piezoelectric pressure sensors and 1000-ohm platinum RTD.

Meter NPS 1/2 through NPS 12 (DN 15 through DN 300).

Each meter shall be factory calibrated at five points from Zero to 250 fps (0 to 76 m/s) and tagged accordingly against the manufacturer's flow standards. The manufacturer shall provide a certificate of calibration for meter.

Each meter shall be programmed using project-specific application data.

Meter shall include integral diagnostics to verify installation conditions and proper operation.

Performance:

Volumetric Flow Accuracy for Liquid: Within 0.75 percent of reading for Reynolds numbers 20000 and larger.

Volumetric Flow Accuracy for Steam and Gas: Within 1 percent of reading for Reynolds numbers 20000 and larger.

Mass Flow Accuracy for Steam and Gas: Within 1.5 percent of reading for Reynolds numbers 20000 and larger.

Repeatability: Within 0.1 percent.

Long-Term Stability: Within 0.1 percent per year.

Ambient Temperature: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

Process Temperature: Minus 40 to plus 464 deg F (Minus 40 to plus 240 deg C).

Pressure: Equal to flange rating.

Output Signals:

Analog Current Signal of Flow Rate:

Two-wire, 4- to 20-mA dc current source.

Signal capable of operating into 1000-ohm load.

Analog Current Signals for Pressure and Temperature: Separate 4- to 20-mA signals for gage pressure and temperature.

Digital Signal:

Pulse output for flow totalization. Two wire, scaled pulse, 0.5 Hz, 100 mA at 30-V dc.

HART, FSK protocol.

Operator Interface:

Keypad.

Digital Display: Two-line digital display of alphanumerical characters. The meter shall display flow rate, flow totalization, pressure, temperature, and support field programming of all parameters.

Construction:

Material: Type 316L stainless steel.

Connection: [**Class 150**] [**Class 300**] [**Class 600**] flange.

Enclosure:

Epoxy-painted cast aluminum.

Removable screw-on cover.

NEMA 250, Type 6.

Electrical Connection: Screw terminals.

Conduit Connection: Two, 1/2-inch (16-mm) trade size.

Upstream Flow Straightener:

Meter manufacturer shall provide flow straightener where required by installation to comply with manufacturer's installation recommendations.

Straightener shall be wafer type, constructed of Type 304 stainless steel, designed to be installed between field-installed flanges.

Straightener size shall match meter size.

* + - * 1. Vortex Shedding Flow Meter for Hazardous Environments:

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

Dwyer Instruments

Rosemount; Emerson Process Management

Sierra Instruments

Approved equivalent.

Requirements in remaining subparagraphs below are based on Rosemount's "8800C Series."

Standard: ASME MFC-6M.

Description:

FM Approved for hazardous environments.

Intrinsically safe for Class I, Division 1, Groups A, B, C, and D; Class II and III, Division 1, Groups E, F, and G.

Explosion-Proof for Class I, Division 1, Groups B, C, and D.

Dust-Ignition-Proof for Class II and III, Division 1, Groups E, F, and G.

Sensor shall be isolated from process and replaceable without breaking process seals.

Meter immune to vibration.

Clog-free design eliminates gaskets and ports.

Meter NPS 1/2 through NPS 12 (DN 15 through DN 300).

Each meter shall be factory calibrated and provided with a certificate of calibration.

Meter shall be furnished with a permanently attached stainless steel tag.

Meter shall include integral diagnostics to verify proper operation.

Performance:

Flow Accuracy: Within 0.65 percent of reading plus 0.025 percent of span for Reynolds numbers 20000 and larger.

Repeatability: Within 0.1 percent of flow rate.

Long-Term Stability: Within 0.1 percent of flow rate per year.

Response Time: Greater of three vortex shedding cycles or 0.2 seconds.

Dampening: Adjustable between 0.2 to 255 seconds.

Ambient Temperature: Minus 58 to plus 250 deg F (Minus 50 to plus 121 deg C).

Humidity: Zero to 95 percent noncondensing.

Process Temperature: Minus 40 to plus 450 deg F (Minus 40 to plus 232 deg C).

Pressure: Equal to flange rating.

Output Signals:

Analog Current Signal of Flow Rate:

Two-wire, 4- to 20-mA dc current source.

Signal capable of operating into 1000-ohm load.

Digital Signal:

Pulse output for flow totalization.

HART protocol.

Digital Display: Digital display of alphanumerical characters. The meter shall display flow rate, flow totalization, percent of range, and current output.

Body and Flanges:

Material: Type 316L stainless steel.

Connection: ASME B16.5, [**Class 150**] [**Class 300**] [**Class 600**] flange.

Enclosure:

Polyurethane-painted cast aluminum.

Removable screw-on cover.

NEMA 250, Type 4X.

Electrical Connection: Screw terminals.

Conduit Connection: 1/2-inch (16-mm) trade size.

* + - 1. LIQUID FLOW SENSORS (PRIMARY ELEMENTS)
				1. Averaging Pitot Tubes:

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

Dwyer Instruments

Emerson Process Management

Rosemount; Emerson Process Management.

Approved equivalent.

Requirements in remaining subparagraphs below are based on Rosemount's "Model 485 Annubar."

Standards: ASME MFC-12M.

Description:

Sensor shall include isolation valves and connections that are suitable for connecting to a remote pressure instrument.

Sensor shall consist of high- and low-pressure plenums and be able to accommodate an integral RTD.

Sensor's cross-sectional tee shape shall allow flow separation at a fixed point independent of flow rate, pressure, or temperature with a stable flow coefficient maintained over a wide range of Reynolds numbers.

Sensor shape shall promote less-turbulent zones on the backside of the sensor. Individual sensing ports shall be located in this less-turbulent region to measure low pressure. Number of sensing ports shall be a function of the pipe size.

High pressure shall be measured by a frontal slot design extending full length of sensor. Number of slots shall be a function of pipe size.

Manufacturer shall submit on request independent testing documentation (product test reports), demonstrating compliance with specified performance.

Retain option in "Performance" Subparagraph below to require "Product Test Reports" Paragraph specified in "Informational Submittals" Article.

Performance:[**Product test reports are required.**]

Discharge Coefficient Factor: Within 0.75 percent of flow rate.

Repeatability: Within 0.1 percent.

Flow Turndown: 10:1.

Sensor Size for Pipe Size NPS 2 through NPS 8 (DN 50 through DN 200): Minimum rod Reynolds number of 6000; probe width of 0.59 inch (15 mm).

Sensor Size for Pipe Size NPS 6 through NPS 36 (DN 150 through DN 900): Minimum rod Reynolds number of 12500; probe width of 1.060 inch (27 mm).

Sensor Size for Pipe Size NPS 12 through NPS 72 (DN 300 through DN 1800): Minimum rod Reynolds number of 25000; probe width of 1.953 inches (50 mm).

Process Temperature Limit: 500 deg F (260 deg C).

Process Pressure Limit: Equal to flange rating.

Construction:

Sensor Surface Finish: Front surface textured for high-Reynolds-number applications to create a more turbulent boundary layer on front surface of sensor and produce a more predictable and repeatable separation of flow at edge of sensor.

Sensor Material: Type 316 stainless steel.

Packing Gland:

Wetted Parts: Type 316 stainless steel.

Packing Material: Graphite.

Isolation Valve: Type 316 stainless steel full port ball valve configured to remove sensor while isolating process.

Flanged In-line Pipe Spool:

Mount sensor in a flanged section of pipe.

Pipe material to match adjacent pipe.

Flanges to match adjacent pipe.

* + - * 1. Venturis:

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

Presco Meters

Primary Flow Signal, Inc.

Approved equivalent.

Requirements in remaining subparagraphs below are based on Preso Meter's "Model VB, CV and SSM Series."

On request, submit independent testing documentation (product test reports), demonstrating compliance with specified performance.

Standard: ASME MFC-3M.

Performance:

Accuracy within 0.5 percent of measured flow throughout flow range from design to 10 percent of design flow.

Accuracy with five pipe diameters of straight pipe upstream and two pipe diameters downstream.

Size and beta ratio shall be matched with transmitter to provide accuracy of entire assembly within 1 percent of design flow rate, when the flow rate is allowed to vary between 10 to 100 percent of the design.

Construction:

One-piece bronze or brass construction with threaded connections for pipe sizes NPS 1/2 through NPS 2 (DN 15 to DN 50).

One-piece plated cast steel with flanged connections for pipe sizes NPS 2-1/2 through NPS 8 (DN 65 to DN 200), and fabricated steel with flanged connections for larger sizes.

Sensing Taps: Two, accurately located built-in sensing taps, nipples, shut-off valves, and quick connect coupling.

Identification Tag: Attached to each venturi with a chain and label indicating pipe size, venturi series, station identification, and meter reading at flow rate and pressure differential.

Use venturi with pressure differential transmitter.

* + - * 1. Orifice Plates:

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

Dwyer Instruments

Primary Flow Signal

Rosemount; Emerson Process Management.

Approved equivalent.

Requirements in remaining subparagraphs below are based on Rosemount's "Model 405 Series."

Standards: ASME MFC-3M or ASME MFC-14M.

Performance:

Orifice plates shall be sharp, square-edged concentric type.

Shop fabricate and calibrate orifice meter runs through NPS 2 (DN 50).

Field fabricate orifice runs NPS 3 (DN 80) and larger.

Meter run piping or tubing shall be uniform internal surface, which is free of internal grooves and striations, but is not polished. Out of roundness shall not exceed 0.5 percent. A reduction of the pipe diameter or distortion caused by welding is unacceptable.

Size orifice plates for 100-inch wg (24.9-kPa) pressure differential, except that the absolute value of the meter range shall not exceed the absolute value of the flowing pressure.

Ratio of orifice diameter to actual internal pipe diameter d/B (beta) shall be between 0.70 and 0.30.

Locate orifice plates in horizontal or vertical lines in accordance with good metering practice.

Minimum upstream and downstream straight pipe shall comply with ASME Fluid Meters Research Committee Reports.

Construction:

Fabricate the orifice plate and matching companion flanges of Type 316 stainless steel.

Transmitter connection shall be at least NPS 1/2 (DN 15).

Stamp the orifice plates with the number and the orifice bore on the handle of the plate.

Use orifice plate with pressure differential transmitter.

Calibration information and calculations shall comply with either of the referenced standards for each orifice plate.

* + - * 1. Segmented Wedge Flow Sensor:

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

Emerson Process Management

OMEGA Engineering

Preso Meters

Approved equivalent.

Requirements in remaining subparagraphs below are based on Preso Meter’s “COIN Series.”

Description: Pressure differential design using a segmented or segmental wedge installed in a straight section of pipe.

Retain option in “Performance” Subparagraph below to require “Product Test Reports” Paragraph specified in “Informational Submittals” Article.

Performance:[**Product test reports are required.**]

Accuracy within 0.5 percent of the measured flow over flow range from design flow to 10 percent of design flow.

Accuracy with 10 pipe diameters of straight pipe upstream and five pipe diameters downstream.

Repeatability shall be within 0.2 percent over flow range.

Discharge coefficient shall be linear and stable throughout the flow range.

Determine H/ID ratios to meet specified performance.

Capable of bi-directional flow measurement with no degradation of performance, with flow in either direction.

Suitable for working pressure of 200 psig at 200 deg F (1379 kPa at 93 deg C).

Construction:

Pipe: Type 316 stainless steel with inside diameter to match adjacent pipe. Length determined by manufacturer.

Wedge: Type 316 stainless steel segmented angled wedge equal on both sides.

Flanges: Class 150 [**weld neck**] [**raised face**], Type 316 stainless steel.

Instrument Connections: NPS ½ (DN 15), Class 3000, Type 316 stainless steel half couplings.

Identification Tag: Stamped or engraved stainless steel.

Use with a pressure differential transmitter.

Retain “Portable Meter Package for Liquid Flow Sensors” Paragraph below to require portable meter package.

* + - * 1. Portable Meter Package for Liquid Flow Sensors:

Metal-reinforced-plastic carrying case.

Waterproof meter with nominal 6-inch (150-mm) round dial face.

Meter with dual rupture-proof liquid-filled bellows having integral temperature compensation.

Meter with external range and zero adjustment.

Multiple meters in package, if required to accommodate venturis with a wide range of pressure signals.

Two connecting hoses, [**10-feet (3-m)**] <**Insert dimension**> long, with quick connect couplings compatible with venturi couplings.

Two brass blowdown valves with Buna-N seals and blowdown hoses.

Instruction book with flow versus differential curves.

Suitable for working pressure of 200 psig (1380 kPa) at 200 deg F (93.3 deg C).

Portable meter package to connect to flow sensor without disturbing connection to pressure differential transmitter. Provide isolation valves at connections.

Turn over to Director’s Representative at Project completion.

* + - 1. LIQUID FLOW SWITCHES
				1. Liquid Flow Switch (Bellows Type):

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

Johnson Controls

Penn Controls

W.E. Anderson; Dwyer Instruments, Inc.

Approved equivalent.

Requirements in remaining subparagraphs below are based on W. E. Anderson's "Series FS-2."

Description:

Field-adjustable four-vane combinations.

Field-adjustable set-point adjustment screw.

Suitable for pipe sizes NPS 1 through NPS 8 (DN 25 through DN 200).

Switch mounted vertically in horizontal pipe.

Performance:

Flow Rate Actuation and De-actuation: Varies with vane combination and set-point adjustment.

Pressure Limit: 145 psig (1000 kPa).

Temperature Limit: 230 deg F (110 deg C).

Electrical Rating: 10 A resistive, 3 A conductive at 250-V ac.

Switch Type: SPDT snap switch.

Wetted Parts Construction:

Bellows: Tin-bronze.

Vanes: Stainless steel.

Body: Forged brass.

Process Connection: NPS 1 (DN 25).

Enclosure:

Die-cast aluminum alloy.

NEMA 250, Type 4.

Electrical Connection: Cable gland with attached wire leads.

* + - * 1. Liquid Flow Switch (Magnetic Type):

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

Johnson Controls

Penn Controls

W.E. Anderson; Dwyer Instruments, Inc.

Approved equivalent.

Requirements in remaining subparagraphs below are based on W. E. Anderson's "Series V4."

Description:

Field-adjustable five-vane combinations.

Suitable for pipe sizes NPS 1-1/2 through NPS 20 (DN 40 to DN 500).

Mounting Suitable for Application: Switch vertically mounted in horizontal pipe, or switch horizontally mounted in vertical pipe with flow up.

Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous-environment Class I, Groups C and D; Class II, Groups E, F, and G.

Performance:

Flow Rate Actuation and De-actuation: Varies with vane combination.

Pressure Limit: 1000 psig (6895 kPa) for brass body, 2000 psig (13790 kPa) for Type 316 stainless steel body.

Temperature Range: Minus 4 to plus 275 deg F (Minus 20 to plus 135 deg C).

Electrical Rating: 10 A at 125/250-V ac.

Switch Type: [**SPDT**] [**DPDT**] snap switch.

Wetted Parts Construction:

Vanes: Type 316 stainless steel.

Body: [**Brass**] [**Type 316 stainless steel**].

Magnetic Keeper: [**Type 430 stainless steel**] [**Type 316 stainless steel**].

Process Connection: NPS 1-1/2 (DN 40).

Enclosure:

Die-cast aluminum alloy.

Threaded cover.

NEMA 250, Type 4.

Electrical Connection: Terminal block.

Conduit Connection:3/4-inch (21-mm) trade size.

* + - * 1. Liquid Flow Switch (Magnetic Type) for Small-Diameter Pipe:

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

Johnson Controls

Penn Controls

W.E. Anderson; Dwyer Instruments, Inc.

Approved equivalent.

Requirements in remaining subparagraphs below are based on "W. E. Anderson's "Series V6."

Description:

Suitable for pipe sizes NPS 1/2 through NPS 2 (DN 15 through DN 50).

Mounting Suitable for Application: Switch vertically mounted in horizontal pipe, or switch horizontally mounted in vertical pipe with flow up.

Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous-environment Class I, Groups A, B, C, and D; Class II, Groups E, F, and G.

Performance:

Flow Rate Actuation and De-actuation: Not adjustable.

Pressure Limit of Body: 1000 psig (6895 kPa) for brass, 2000 psig (13790 kPa) for Type 303 stainless steel body.

Pressure Limit of Tee: 250 psig (1724 kPa) for brass, 1000 psig (6895 kPa) for malleable iron, and 2000 psig (13790 kPa) for forged carbon steel and stainless steel.

Temperature Range: Minus 4 to plus 220 deg F (Minus 20 to plus 104 deg C).

Electrical Rating: 5 A at 125/250-V ac.

Switch Type: [**SPDT**] [**DPDT**] snap switch.

Wetted Parts Construction (Lower Body):

Vanes: Type 301 stainless steel.

Body: [**Brass**] [**Type 303 stainless steel**].

Magnet: Ceramic.

Process Connection: NPS 1/2 (DN 15).

Enclosure (Upper Body):

[**Brass**] [**Type 303 stainless steel**].

NEMA 250, Type 4.

Electrical Connection: Terminal block.

Conduit Connection: 3/4-inch (21-mm) trade size.

Integral Mounting Tee Furnished with Switch:

[**Brass**] [**Forged carbon steel**] [**Malleable iron**] [**Stainless steel**].

Size: [**Match adjacent pipe**] <**Insert size**>.

Connection: Threaded pipe.

* + - 1. LIQUID FLOW TRANSMITTERS
				1. Pressure Differential Transmitter with 0.07 Percent Accuracy for Flow Measurement [**in Hazardous Environment**]:

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 below are based on Rosemount's "Model 3051CD."

Retain first subparagraph below for transmitters located in hazardous environments.

FM Approved for hazardous environments.

Intrinsically safe for Classes I, II, and III, Divisions 1 and 2, Groups A through H.

Explosion-Proof for Class I, Division 1, Groups B, C, and D.

Dust-Ignition-Proof for Class II, Division 1, Groups E, F, and G.

Dust-Ignition-Proof for Class III, Division 1.

Performance:

Range: Minus 250- to 250-inch wg (Minus 62.5 to 62.5 kPa).

Span: Field adjustable.

Minimum Span: 2.5-inch wg (500 Pa).

Accuracy: Within 0.07 percent of span or better.

Stability: Within 0.125 percent of upper range limit for 5 years.

Overpressure Limits: 3626 psig (25000 kPa).

Process Temperature Limits: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).

Ambient Temperature Limits: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.

Shock and vibration shall not harm the transmitter.

Analog Output Current Signal:

Two-wire, 4- to 20-mA dc current source.

Signal capable of operating into 1000-ohm load.

Digital signal based on HART protocol carried with current signal.

Dampening: Field selectable zero to 30 seconds.

Operator Interface: Zero and span adjustments located behind cover.

Retain "Display" Subparagraph below for display.

Display: Five-digit, two-line digital display with 0.4 inch (10 mm) high alphanumeric characters.

Construction:

Nonwetted parts of transmitter constructed of aluminum or stainless steel.

Enclosure with removable cover on each side.

Wetted parts of transmitter constructed of Type 316 stainless steel.

NPS 1/2 (DN 15) process connections on bottom of instrument.

Drain/vent valve on low- and high-pressure connections.

Two 1/2-inch (16-mm) trade size conduit connection on side of instrument enclosure.

Screw terminal block for wire connections.

NEMA 250, Type 4X.

Mounting bracket suitable for installation.

Retain "Five-Valve Manifold" Subparagraph below for five-valve manifold.

Five-Valve Manifold:

Each transmitter shall have integrally mounted manifold.

Construct manifold body of Type 316 stainless steel.

Manifold shall have NPS 1/2 (DN 15) process connections.

* + - * 1. Liquid Pressure Differential Transmitter for Flow Measurement:

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

Dwyer Instruments, Inc.

OMEGA Engineering

Red-White Valve Corp.

Approved equivalent.

Requirements in remaining subparagraphs below are based on Dwyer's "Series 645."

Performance:

Range: Approximately 2 times the set point.

Span: Adjustable plus or minus 1 mA, non-interactive.

Accuracy: Within 0.25 percent of full scale.

Maximum Operating Pressure: 2.5 times range.

Temperature Limits: Zero to 175 deg F (Minus 18 to plus 79 deg C).

Compensate Temperature Limits: 30 to 150 deg F (Minus 1 to plus 66 deg C).

Thermal Effects: 0.02 percent of full scale per degree F.

Response Time: 30 to 50 ms.

Shock and vibration shall not harm the transmitter.

Analog Output Current Signal:

Two wire, 4- to 20-mA dc current source.

Signal capable of operating into 1000-ohm load.

Operator Interface:

Zero and span adjustments located behind cover.

Bleed screws on side of body, two screws on low-pressure side and one screw on high-pressure side, for air in line and pressure cavity.

Construction:

Aluminum and stainless steel enclosure with removable cover.

Wetted parts of transmitter constructed of 17-4 PH or 300 series stainless steel.

NPS 1/4 (DN 8) process connections on side of instrument enclosure.

Knock out for 1/2-inch (15-mm) trade size conduit connection on side of instrument enclosure.

Screw terminal block for wire connections.

NEMA 250, Type 4X.

Mounting bracket shall be suitable for installation.

Retain subparagraph below for optional three-valve manifold.

Transmitter shall have three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Manifold shall have NPS 1/4 (DN 8) process connections.

1. EXECUTION
	* + 1. EXAMINATION
				1. Examine substrates and conditions, with Installer present, 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. Provide the services of an independent inspection agency to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on shop drawings.

Do not begin installation without submittal approval of mounting location.

* + - * 1. 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.
				2. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
				3. Proceed with installation only after unsatisfactory conditions have been corrected.

Retain "Instrument Applications" Article below unless all requirements for instruments for different applications are indicated on Drawings. Where Drawings indicate only some requirements, revise this article accordingly.

Options indicated in "Instrument Applications" Article are provided where multiple product options are specified. Where only a single product is specified for an instrument type, that product is not included in "Instrument Applications" Article.

* + - 1. INSTRUMENT APPLICATIONS

Retain first paragraph below and delete subsequent subparagraphs if requirements are delegated to Contractor. Delete this article if instrument types are indicated on Drawings.

* + - * 1. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
				2. Thermal Airflow Measurement Stations:

For Air-Ducted/Plenum:

Measured Velocities Greater Than 200 fpm (1.0 m/s**)**: Thermal airflow measurement station.)

Provide a remotely mounted microprocessor-based transmitter at each measurement location.

For Air-Ducted/Plenum - Duct Size 2 sq. ft. (0.18 sq. m)or Less:

Measured Velocities Less Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)

Provide a remotely mounted microprocessor-based transmitter at each measurement location.

For Supply or Return Fan Array:

Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)

Provide a remotely mounted microprocessor-based transmitter at each measurement location.

For Supply or Return Fan, Single-Width Single-Inlet (SWSI) or Double-Width Double-Inlet (DWDI) Fans:

Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)

Provide a remotely mounted microprocessor-based transmitter at each measurement location.

For Air Terminal Units:

Measured Velocities Greater Than 200 fpm (1.0) m/s): Thermal airflow measurement station.

Provide a microprocessor-based transmitter at each measurement location.

For Packaged HVAC Units, 12.5 Tons (44.0 kW)or Smaller:

Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)

Provide a remotely mounted microprocessor-based transmitter at each measurement location.

For Directional Airflow Sensors:

Measured Velocities Greater Than 50 fpm (0.25 m/s): Thermal airflow measurement station.

Provide a remotely mounted microprocessor-based transmitter at each measurement location.

For Data Center Server Rack Airflow/Pressure and Temperature Monitor:

Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)

Provide a remotely mounted microprocessor-based transmitter at each measurement location.

For Damper-Mounted Airflow Stations:

Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)

Provide a remotely mounted microprocessor-based transmitter at each measurement location.

* + - * 1. Duct-Mounted Airflow Sensors:

Measured Velocities [**500 fpm (2.5 m/s)**] <**Insert value**> and Less: Thermal airflow station.

Review operating velocity range with instrument manufacturers to ensure project requirements are achievable. Options indicated below may not be achievable by all products and manufacturers.

Measured Velocities Greater than [**500 fpm (2.5 m/s)**] <**Insert value**>: [**Pitot-tube airflow sensor station**] [**Thermal airflow station**].

* + - * 1. Damper-Mounted Airflow Sensors:

Measured Velocities [**400 fpm (2.0 m/s)**] <**Insert value**> and Less: Thermal airflow station.

Review operating velocity range with instrument manufacturers to ensure project requirements are achievable. Options indicated below may not be achievable by all products and manufacturers.

Measured Velocities Greater than [**500 fpm (2.5 m/s)**] <**Insert value**>: [**Pitot-tube airflow sensor station**] [**Thermal airflow station**] [**Damper with integral flow measurement**] [**Damper with integral flow control**].

* + - * 1. Fan-Mounted Airflow Sensors:

Measured Velocities [**500 fpm (2.5 m/s)**] <**Insert value**> and Less: Thermal airflow station.

Review operating velocity range with instrument manufacturers to ensure project requirements are achievable. Options indicated below may not be achievable by all products and manufacturers.

Measured Velocities Greater than [**500 fpm (2.5 m/s)**] <**Insert value**>: [**Pitot-tube fan inlet airflow sensor station**] [**Piezometer ring fan inlet airflow sensor**] [**Thermal airflow station**].

* + - * 1. Airflow Switches:

Measured Velocities 400 fpm (2.0 m/s) and Less: Polymer film sail switch.

Measured Velocities Greater than 400 fpm (2.0 m/s): Stainless steel single-vane switch.

* + - * 1. Airflow Transmitters for Use with Pitot-Tube-Type Sensors:

Copy and revise subparagraphs below to suit each unique application requiring a different airflow transmitter type. Critical applications should use best accuracy transmitter with auto-zero feature.

Exhaust Air Airflow: [**Airflow transmitter with 0.10 percent accuracy and auto-zero feature**] [**Airflow transmitter with 0.25 percent accuracy and auto-zero feature**] [**Pressure differential transmitter for airflow measurement**] [**Pressure differential indicating transmitter, switch and controller for airflow measurement**].

Outdoor Air Airflow: [**Airflow transmitter with 0.10 percent accuracy and auto-zero feature**] [**Airflow transmitter with 0.25 percent accuracy and auto-zero feature**] [**Pressure differential transmitter for airflow measurement**] [**Pressure differential indicating transmitter, switch and controller for airflow measurement**].

Return Air Airflow: [**Airflow transmitter with 0.10 percent accuracy and auto-zero feature**] [**Airflow transmitter with 0.25 percent accuracy and auto-zero feature**] [**Pressure differential transmitter for airflow measurement**] [**Pressure differential indicating transmitter, switch and controller for airflow measurement**].

Supply Air Airflow: [**Airflow transmitter with 0.10 percent accuracy and auto-zero feature**] [**Airflow transmitter with 0.25 percent accuracy and auto-zero feature**] [**Pressure differential transmitter for airflow measurement**] [**Pressure differential indicating transmitter, switch and controller for airflow measurement**].

* + - * 1. Liquid Flow Sensors (Primary Elements):

Copy and revise subparagraph below to suit each system and unique applications requiring a different type of liquid flow sensor (primary element). Where "(Insert system)" is indicated, insert system type: "Chilled," "Condenser," "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**>: [**Averaging pitot tubes**] [**Venturis**] [**Orifice plates**] [**Segmented wedge**].

* + - * 1. Liquid Flow Meters:

Copy and revise subparagraph below to suit each system and unique applications requiring a different type of liquid flow meter. Where "(Insert system)" is indicated, insert system type: "Chilled, "Condenser, "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**>: [**Insertion paddle wheel transmitter**] [**Turbine flow meter**] [**Electromagnetic flow meter**] [**Vortex shedding flow meter with integral temperature measurement**] [**Vortex shedding flow meter with integral pressure and temperature measurement**] [**Vortex shedding flow meter for hazardous environments**].

* + - * 1. Liquid Flow Switches:

Copy and revise subparagraph below to suit each system and unique applications requiring a different type of liquid flow switch. Where "(Insert system)" is indicated, insert system type: "Chilled, "Condenser, "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**>: [**Bellows type**] [**Magnetic type**].

* + - * 1. Liquid Flow Transmitters:

Copy and revise subparagraph below to suit each system and unique applications requiring a different type of liquid flow transmitter. Where "(Insert system)" is indicated, insert system type: "Chilled, "Condenser, "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**>: [**Pressure differential transmitter with 0.07 percent accuracy for flow measurement**] [**Liquid pressure differential transmitter**].

* + - 1. INSTALLATION, GENERAL
				1. Provide products required to satisfy more stringent of all requirements indicated.
				2. Install products level, plumb, parallel, and perpendicular with building construction.
				3. 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.
				4. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
				5. Install products in locations that are accessible and that will 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.
				6. Corrosive Environments:

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

If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:

Laboratory exhaust airstreams.

Process exhaust airstreams.

<**Insert requirement**>.

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

Where instruments are located in a corrosive environment and are not corrosive resistant from the 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. INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS
				1. Mounting Location:

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

Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings 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 flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

Install airflow 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 not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

Install instruments in steam, liquid, and liquid-sealed-piped services below their process connection point. Slope tubing down to instrument with a slope of [**2**] [**3**] <**Insert number**> percent.

Install instruments in dry gas and non-condensable-vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of [**2**] [**3**] <**Insert number**> percent.

* + - * 1. Mounting Height:

Mount 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, state, and federal accessibility requirements, within a range of 42 to 72 inches (1050 to1800 mm) above the adjacent floor, grade, or service catwalk or platform.

Make every effort to mount at 60 inches (1500 mm).

* + - * 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.
			1. FLOW INSTRUMENTS INSTALLATION
				1. Airflow Sensors:

Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.

Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

* + - * 1. Liquid and Steam Sensors:

Install sensors in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.

Alert manufacturer where installation cannot accommodate recommended clearance, and solicit recommendations for field modifications to installation, such as flow straighteners, to improve condition.

Install pipe reducers for in-line sensors smaller than line size. Position reducers at distance from sensor to avoid interference and impact on accuracy.

Install in-line sensors with flanges or unions to provide drop-in and -out installation.

* + - * 1. Liquid Flow Meters:

Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.

Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.

Install in-line meters with flanges or unions to provide drop-in and -out installation.

Insertion Meters:

Install system process connections full size of meter connection, but not less than [**NPS 1 (DN 25)**] [**NPS 1-1/2 (DN 40)**] [**NPS 2 (DN 50)**] <**Insert pipe size**>. Provide [**stainless steel**]bushing if required to mate to system connection.

Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.

In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

* + - * 1. Liquid Switches:

Install system process connection full size of switch connection, but not less than [**NPS 1 (DN 25)**] [**NPS 1-1/2 (DN 40)**] [**NPS 2 (DN 50)**] <**Insert pipe size**>. Install [**stainless steel**]bushing if required to mate switch to system connection.

Install switch in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.

In applications where top-dead-center location is not possible due to field constraints, install switch at location along top half of pipe if switch is acceptable by manufacturer for mounting orientation.

* + - * 1. Transmitters:

Install airflow transmitters serving an air system in a single location adjacent to or within system control panel.

Install liquid flow transmitters, not integral to sensors, in vicinity of sensor. Where multiple flow transmitters serving same system are located in same room, co-locate transmitters by system to provide service personnel a single and convenient location for inspection and service.

* + - 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. CHECKOUT PROCEDURES
				1. Description:

Check out installed products before continuity tests, leak tests, and calibration.

Check instruments for proper location and accessibility.

Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

* + - * 1. Flow Instrument Checkout:

Verify that sensors are installed correctly with respect to flow direction.

Verify that sensor attachment is properly secured and sealed.

Verify that processing tubing attachment is secure and isolation valves have been provided.

Inspect instrument tag against approved submittal.

Verify that recommended upstream and downstream distances have been maintained.

* + - 1. 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 recommendations.

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-resistant 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. 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 factory-authorized service field advisor to train**] [**Train**] Director’s Representative's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
				2. Coordinate video with operation and maintenance manuals and classroom instruction for use by Director’s Representative in operating, maintaining, and troubleshooting.
				3. Record videos on DVD disks.
				4. Director’s Representative shall have right to make additional copies of video for internal use without paying royalties.
				5. Director’s Representative shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.14