SECTION I2
GENERAL INSTRUMENTATION REQUIREMENTS

1. INSTRUMENTATION: Instrumentation components furnished with the Equipment shall be in accordance with the following Articles and shall be constructed to withstand the temperatures, pressures and other environmental conditions, including vibration, encountered in the actual service. Instruments and devices shall be suitably protected for shipment and the rigors of construction. Explosion proof construction shall be furnished where required by applicable code or the detailed Specifications.

1.1 The instrumentation shall be designed in such a way that no single control system, instrument failure, controller failure, fuse, or circuit breaker shall interrupt the operation of more than one piece of redundant equipment.

1.2 Instruments shall be provided from the manufacturers listed within each Article below. For instruments not specified below, refer to the approved equipment supplier's information within Section GR-A – General Description and Scope of Work. For instruments that are not specified below or within the Approved Equipment Suppliers list, the Seller shall request Buyer approval.

1.3 All instrumentation shall be certified, labeled, designed, built, rated, and tested in accordance with the latest revision of the applicable local and ANSI standards. Components that are standard UL listed and labeled shall be provided where routinely available. When a vendor supplied control system has been provided all instruments shall be wired to the vendor supplied control system. Skid mounted instruments shall be wired to a common junction box. Instrument analog signals for electronic instrument systems shall be 4 to 20 mA DC. Instrument analog signals for pneumatic instrument systems shall be 3 to 15 psig (20.7 to 103.4 kPag). Use of pneumatic controls shall be approved by Buyer prior to use.

1.4 All process control units of measurement shall be English. All instrumentation, devices, monitors and indicators shall be English. All instrument drawings, specifications, calculations and documentation shall be prepared in English and Metric units. All documentation shall be in the English language. The following table details specific units per measurement parameter. If measurements for something other than what is listed below are required, the units shall be submitted to the Buyer for approval.

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Parameter	Units of Measurement (English)
Temperature	Degrees Fahrenheit (°F)
Pressure	Pounds per square inch gauge (psig)
	Inches of water column (in wc) or (inH_2O)
	Pounds per square inch absolute (psia)
	Inches of mercury absolute (in HgA)
Level	
General	Percent, inches, feet
Tank Gauge	Linear feet, inches, and tenths of inches
Deviation from normal level	Percent
Flow	
Liquids	Gallons per minute (gpm)
	Pounds per hour (pph or #/hr)
Gases and Vapors	Standard cubic feet per minute at 60°F (SCFM)
	Standard cubic feet per hour at 60°F (SCFH)
Steam & Boiler Feedwater	Pounds per hour (pph or #/hr)
Solids	Tons per hour (tph)
	Tons per day (tpd)
Steam & Water Sampling	
PH	pH (pH Units)
Specific conductivity	µS/cm
Cation conductivity	µS/cm

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Parameter	Units of Measurement (English)
Degassed cation conductivity	µS/cm
Dissolved oxygen	Parts per billion (ppb)
Silica or sodium	Parts per billion (ppb)
Oxygen scavenger	Parts per billion (ppb)
Sulfate, phosphate, chloride	Parts per billion (ppb)
Turbidity	NTU
Total Suspended Solids (TSS)	mg/L

1.5 Calibration: All instruments shall be factory calibrated and provided with certified calibration sheets as specified in Section GR-B – Engineering Data and Submittal Schedule.

1.6 Instrument Tags: Each instrument shall have a stainless steel instrument tag permanently attached to them. If this is not possible, the instrument tag shall be fastened to the instrument with stainless steel wire. The instrument tag shall be stamped or etched with the instrument identification number (tag number). This tag is in addition to the nameplate, which provides the manufacturer's model number and other data. Phenolic laminated nameplates shall be provided for each board or locally mounted instrument indicating tag number, service and pertinent information such as chart factors if required.

1.7 Sealant: For threaded assemblies, use the appropriate sealing compound for the design service temperature and pressure.

1.8 Mounting: Instruments shall be installed in readily accessible locations, as defined by the National Electrical Code. Instrument locations shall be coordinated with the Buyer to verify suitability.

Type	Manufacturer	Model	Device Type	Device Rev
Pressure (Gauge/ABS/DP)	Rosemount (Emerson)	2051	\3051	02
Temperature Transmitter	Rosemount (Emerson)	3144P	\3144	03
Temperature (Multiplexer)	Rosemount (Emerson)	848T	\0848	08

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Level (Guided Wave Radar)	Rosemount (Emerson)	5301	5300	04
Level (Radar, Non-Contact)	Rosemount (Emerson)	5408	\5400	04
Analyzer - Contacting Conductivity, pH	Rosemount (Emerson)	5081	\4084	03
Flow (Vortex)	Rosemount Inc.	8800D	\8800	10
Temperature (Dual)	Rosemount Inc.	214C	\214	02
Coriolis	Emerson Micro Motion	MVD 2700	\2000	08

1.9 TRANSMITTERS: Transmitters that do not interface with the ST, shall be loop powered, two-wire type, with 4-20 mA output signals and 12 to 42 VDC power supply capable of driving a load of up to 750 ohms. Transmitters using a digital signal based on HART Protocol shall be supplied. All transmitters shall have a housing with a minimum rating of NEMA 4X and shall be provided with local indication. Unless the process dictates otherwise; the body, wetted trim, and process connections materials shall be 316 stainless steel at a minimum. Accuracy of electronic transmitters shall be ±0.10% of range or better and repeatability shall be ±0.10% of range or better. Range span shall be a minimum ratio of 10:1. Wherever possible, conduit size shall be ½ inch (13 mm) NPT. Transmitters shall be suitable for the Area Electrical Classification, if specified.

1.10 Transmitters shall be Rosemount or Buyer approved equal. Pressure and differential pressure transmitters shall be Rosemount 2051 “Smart” transmitters.

1.11 Vortex meters and Mag meters shall be Rosemount or Buyer approved equal.

1.12 Pressure Transmitters: Where freeze protection is required, and the process temperature is less than 400°F, a diaphragm seal with capiliary shall be used. The diaphragm seal and capillary shall be filled with Silicone 200. The diaphragm seal shall be of the flanged type with ½ inch FNPT process connnection.. The diaphragm seal shall be provided with a flushing connection ring with a vent and drain plugs. The seller shall not use tubing to connect a diaphragm seal to a process connection. Where diaphragm seals and capiliary cannot be used, pressure and differential transmitters shall be provided with ASME B31.1 compliant instrument manifolds. Any pressure and differential pressure transmitters without diaphragm seals require Buyer approval. The manifolds shall be 316 stainless steel and have graphite packing or the appropriate material for the process fluid. Process connections on manifolds shall be ½ inch (13 mm) FNPT. Static pressure transmitters shall be equipped with a two-valve manifold, and differential pressure transmitters shall be equipped with a 5 valve manifold. A Male Connector, Swagelok SS-810-1-4, shall be provided and be shop installed in each vent port of the manifold. Pressure transmitters with flanged connections shall be silicone filled and provided with flushing connection ring. Seller shall apply nonreversible temperature labels of an appropriate size to each instrument manifold.

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The label shall be self-adhesive and permanently turn dark when the manifold reaches 300 °F (149 °C).

1.13 Level Transmitters: Sensing elements for level transmitters shall be as follows:

1.13.1 Atmospheric vessel level shall be measured using gauge pressure transmitters, where guided wave radar level transmitters are not practical.

1.13.2 Guided Wave Radar shall be used clean liquid level measurements.

1.13.3 Radar, ultrasonic or guided wave radar level transmitters to be mounted to sump stilling wells shall use a process connection of 4" CL150 FF flanged.

1.14 Flow Transmitters: Flow transmitters, in general, shall be differential pressure types. Square root extraction shall generally be performed electronically in the control system which receives the transmitter differential pressure output signal. However these differential pressure transmitters shall have square root extrapolation capabilities for local flow indication. Flow measurements may be taken from Vortex Flow Meters, Magnetic Flow Meters, Coriolis Mass Flow Meters, differential pressure type instruments as specified in this section, or other Buyer approved technologies as required by the process.

1.14.1 Vortex Flow Meters:

1.14.1.1 The Vortex Flow Meter instrument body and shedder bar shall be made of materials as specified on the Instrument Data Sheet. The flow meter shall be a complete unit ready to install including any calculation factors required for full accuracy.

1.14.1.2 Flow accuracy: Digital and pulse output accuracy shall be at least ±1.0% for liquids and ±1.50% for gases and steam. Analog output accuracy shall be at least ±1.025% for liquids and ±1.525% for gases and steam. Repeatability shall be at least ±0.1%. Stability shall be at least ±0.1% over one year. The suppliers shall provide calculations and K factor coefficients.

1.14.2 Magnetic Flow Meters:

1.14.2.1 Magnetic flow meter lining and electrodes shall be made of materials as specified on the Instrument Data Sheet. The flow meter shall be a complete unit ready to install, including any calculation factors required for full accuracy. When instrument materials or piping materials dictate, grounding rings shall be provided with the flow meter to insure proper grounding for the meter.

1.14.2.2 Flow accuracy, which includes the combined effects of linearity, hysteresis, repeatability, and calibration uncertainty, shall be at least ±0.25% of rate.

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1.14.2.3 The transmitter head shall meet the requirements for transmitters previously stated. Transmitters shall typically be mounted directly to the flow tube, but may be mounted remotely. If mounted remotely the cable connecting the flow tube with the transmitter shall be supplied. The Data Sheet will specify local or remote transmitter mounting and the length of cable required for a remote mounted unit.

1.14.2.4 The transmitter shall provide a frequency output as well as a 4-20 mA analog signal. The transmitter shall provide an empty pipe detection feature that sets the outputs to indicate zero flow values. The circuitry shall also detect an open electrode connection.

1.14.3 Coriolis Mass Flow Meters:

1.14.3.1 Coriolis mass flow meters materials of construction shall be as specified on the Instrument Data Sheet. The flow meter shall be a complete unit ready to install, including any calculation factors required for full accuracy and shall be furnished as a flanged style spool for inline installation.

1.14.3.2 Flow accuracy shall be at least ±0.50% for liquids and ±0.75% for gases. Repeatability shall be at least ±0.25% for liquids and ±0.5% for gases.

1.15 Positioners and Position Transmitters: All modulating control valves shall be supplied with Fisher FIELDVIEW DVC6200 series positioners. Positioners shall normally be "motion balance" type and should be securely mounted on the accessory bosses on the valve yoke. Positioners shall be easily converted from direct to reverse acting. Valves specified with a 2:1 booster relay would not require a positioner. Pneumatic modulating control valves shall be supplied with positioners utilizing 4-20 mA DC control signals with HART protocol and output signal range of 4-20 mA DC hardwired output without modification during commissioning. Positioners should indicate green for closed and red for open.

1.15.1 Electro-pneumatic positioners of the digital type shall be provided when specified. Positioners shall accept a 4-20 mA signal provided by the Buyer's control system. Positioners HART protocol shall have communications data capability available on the analog signal wires. Valve position shall be included in the HART data. All modulating control valve position transmitter signals shall be provided on the HART communications to the DCS (available on the two wire demand signal) and output signal range of 4-20 mA DC hardwired output without modification during commissioning. Any valves without this feature shall be noted separately via the valve tag numbers. HART communication shall be revision 6 or higher.

2. GAUGES: Gauges on process piping shall generally be visible 10 feet (3 m) from an operator's normal stance at floor or platform level and shall be resistant to facility atmospheres. Gauge faces shall not be obstructed by equipment, other devices, piping, conduit or supports. Weep holes shall be provided on the case bottom of all gauges located in humid areas unless the case already has sufficient ventilation.

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2.1 Level Gauges: Level gauges shall be suitable for the design and the expected range of service conditions. Gauge glasses used in conjunction with level instruments shall cover a range slightly greater than the highest and lowest trip/alarm setpoints. Level glasses shall be visible from grade, platform, or the related instrument.

2.1.1 Materials of Construction: All metal parts of level gauge glasses and gauge cocks shall be rust proof. Brass and bronze are not acceptable for any wetted parts. Alloy construction (minimum 304 stainless steel) shall be used for all wetted parts where the application requires it, and on applications below 20 °F (-7 °C). Gauges shall have tempered borosilicate glass or equivalent material resistant to thermal and mechanical shock. Glass gauges for high temperature use shall be coated with Mica coating. Gauges for caustic, steam or water service greater than 200 °F (93 °C) shall be furnished with Mica or approved shields.

2.1.2 Level gauges shall be of the following type:

Transparent glass for low temp and pressure:	Translucent or opaque liquids
Reflex glass for:	Transparent liquids

2.1.3 Level gauges shall be supplied with drain valves, shut-offs valves, auto ball check valves and gauge guards. Upper and lower check valves shall be equipped with ASME B31.1 compliant ball checks which, in the event of glass breakage, shall automatically seal to prevent the leakage of vessel contents. Gauge cocks shall be offset pattern type, unless required otherwise by the Seller's design. Visible length is in excess of the maximum operating range.

2.1.4 Level gauges shall be Jerguson or Buyer approved equal.

2.2 Pressure Gauges: Gauges for control air supply and signal pressures integral to the instrument shall be in accordance with the manufacturer's standards. All other gauges shall be 4½ inch (114.3 mm) with markings for approximately 270 degrees of the dial. Ranges shall be selected so that the normal operating pressure appears in the middle third of the dial. Units of measurement shall be shown on the dial face. Dials shall be white with black markings. Accuracy shall be within 0.5% of full scale, per ASME B40.100 Grade 2A. All gauges shall have stainless steel movable parts and ½ inch (13 mm) MNPT process connections. Cases shall be made of phenolic or glass fiber reinforced polypropylene. Gauges shall have externally adjustable pointers. Each gauge case shall have shatterproof glass and a blowout disk in the back. Bourdon tubes shall not contain copper material. For vibration and/or dampen service, the gauge should be liquid filled or manufacturers mechanical option. Diaphragm seals shall be provided for freeze protection, corrosive fluids, and services that can clog the measuring element. Diaphragm seals shall have ½ inch (13 mm) FNPT process connections. Filling fluids shall be silicone or buyer approved fluid to meet the minimum site conditions. Pressure gauge calibration reports showing tag numbers, full calibration information including when and where the calibration occurred shall be supplied. Pigtail siphon tubes shall be provided for all steam pressure measurements. Pressure gauges shall be equipped with a 2 valve manifold. A Bleed

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Valve, Swagelok SS-BVM4, shall be provided to be shop installed in the vent port of the manifold. A Pressure Limiting Valve, Ashcroft 04-PL02-(TBD)-ST-50-(Factory Set Range)-XC3HY shall be provided for when the range is below the design pressure of the line.

- For Steam Service: 1/2 – 14 inch FNPT (13 mm) (Outlet) x 1/2 – 14 inch (13 mm) FNPT (Inlet)
- For Water Service: 1/2 – 14 inch FNPT (13 mm) (Outlet) x 1/2 – 14 inch (13 mm) MNPT (Inlet)
- For Water Service with Diaphragm: 1/2 – 14 inch (13 mm) MNPT (Outlet) x 1/2 – 14 inch (13 mm) MNPT (Inlet).

2.2.1 Pressure gauges shall be Ashcroft or Buyer approved equal.

2.3 Temperature Gauges: Temperature gauges for local mounting shall be bimetallic type with 5 inch (127 mm) dials minimum, white faces, black numerals and graduation markings, and shatterproof glass. Stem diameter shall be 0.250 inch (6.35 mm) OD to fit into a standard 0.260 inch (6.604 mm) bore thermowell with ½ inch (13 mm) MNPT thermowell connection. For high temperatures or for remote mounting, temperature gauges shall be minimum 4½ inch (114.3 mm) dial gas actuated gauges. Stem diameter shall be 0.375 inch (9.525 mm) OD to fit into a standard 0.385 inch (9.779 mm) bore thermowell with ½ inch (13 mm) NPT process connection. Stem material shall be 316 Stainless Steel. Ranges shall be selected so that the normal operating temperature appears in the middle third of the dial. Temperature gauges shall have an external zero adjustment and be of the "every angle" configuration. Accuracy shall be +/- 1.0% of full scale or better. Thermowells shall be furnished for all temperature gauges and shall be as specified in this Section.

2.3.1 Temperature gauges shall be Ashcroft EI case style with union or Buyer approved equal.

2.4 Differential Pressure Gauges: Differential pressure gauges for control air supply and signal pressures integral to the instrument shall be in accordance with the manufacturer's standards. All other gauges shall be 4½ inch (114.3 mm) with markings for approximately 270 degrees of the dial. Ranges shall be selected so that the normal operating pressure appears in the middle third of the dial. Units of measurement shall be shown on the dial face. Dials shall be white with black markings. Accuracy shall be within 1% of full scale, per ASME B40.100 Grade 2A. Differential pressure gauge calibration reports showing tag numbers, full calibration information including when and where the calibration occurred shall be supplied. Diaphragm seals shall be provided for freeze protection, corrosive fluids, and services that can clog the measuring element. Filling fluids shall be silicone or buyer approved fluid to meet the minimum site conditions.

2.4.1 The indicator case shall be constructed of a shock resistant, corrosion resistant, weatherproof material and ½ inch (13 mm) FNPT process connections. The case and window shall be adequately sealed to insure a moisture, fume, and dust free atmosphere for the indicating mechanism. The actuating unit shall be a differential pressure type utilizing a rupture proof bellows assembly. For vibration and/or dampen service, the gauge should be liquid filled or

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manufacturers mechanical option. Differential pressure gauges shall be equipped with a 5 valve manifold. A Male Connector, Swagelok SS-810-1-4, shall be provided and be shop installed in each vent port of the manifold.

2.4.2 Differential pressure gauges shall be Mid-West Instrument or Buyer approved equal.

2.4.3 Ranges shall be selected such that the maximum operating system pressure does not exceed 75% of the full-scale range.

3. SWITCHES: Switch elements shall be one DPDT to actuate at the same set point. Switch elements shall be snap action hermetically sealed elements. Contact ratings shall be 5A at 120 VAC or 0.5 A at 125 VDC. Mercury type switch elements are not acceptable. Switch housings shall be rated NEMA 4X as a minimum. Switch conduit connections shall be ¾ inch (19 mm) FNPT. In general, switches shall be applied such that the actuation point is within the center one-third of the instrument range. Switch action for alarms, shutdowns, and interlocks shall normally be closed circuit at normal operating conditions and open circuit for abnormal condition. Switches shall be suitable for the Area Electrical Classification, if specified. Transmitters shall be used to the greatest extent possible in place of process type switches.

3.1 Limit Switches: Limit switches, when furnished on a control valve, shall be provided for the open and closed position (and intermediate positions where required) of the valve.

3.1.1 When specified, limit switches shall be securely fastened to the valve yoke in such a manner as to not interfere with any valve or accessory function.

3.1.2 Switch settings shall be factory calibrated based on the detailed requirements specified.

3.1.3 Limit switches, when furnished on a modulating 4-20 mA control valve, shall be provided for the open and closed position of the valve.

3.1.4 Motor and solenoid-operated valves and dampers shall have either two or three operator interface functions, i.e. open, close, and auto (if automatic operation is required). Open and closed indications (with both shown when the device is in its intermediate position) shall be indicated for operator feedback.

3.2 Pressure and Differential Pressure Switches: Pressure and differential pressure switches operating mechanisms shall be diaphragm actuator, force-balance piston actuated, or a combination diaphragm-piston actuated, or Buyer approved technology. Unless the process dictates otherwise; the body, diaphragm, wetted components, and process connection material shall be a minimum 316 stainless steel. The switch body and element pressure rating shall be at least 150% of the maximum static operating pressure. All measuring elements shall be able to withstand the full rating of the switch in either direction without damage, without changing

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repeatability or any zero shifts. The switch set point shall be adjustable over the full range of the measuring element.

3.2.1 Pressure connections shall be ½ inch (13 mm) FNPT. Alarm and shutdown switch settings shall not be adjustable from outside the housing.

3.2.2 Pressure and differential pressure switches shall be Ashcroft, SOR, Ametek, or Buyer approved equal.

3.2.3 Pressure switches shall have both a primary and secondary diaphragm. The secondary diaphragm shall prevent process fluid from entering the switch in the event of a leak in the primary diaphragm.

3.3 Level Switches: In general, level switches shall be the external float cage type with side and bottom 1 inch (25 mm) socket weld connections, constructed to ASME B31.1 requirements, and suitable for the pressure, temperature, and general service conditions and functions specified. Internal trim shall be stainless steel unless other materials are required for the service. For high temperature applications, more exotic switches may be required. For design temperatures above 600 °F (315 °C), provide a high temperature junction box with hard conduit pre-wired from switch to junction box and installed to level switch without external support.

3.3.1 Floats shall be fabricated of 316L stainless steel or other material suitable for the process and shall be encased in a cage. All cages shall have a flanged connection to permit removal of the float.

3.3.2 Switch element leads shall be of high temperature construction as required by the service and shall be terminated on terminal blocks within the switch housing.

3.3.3 Float type switches shall be furnished with all the test certificates to meet ASME B31.1 in addition to hydrotest and functional certificates.

3.3.4 Float switches shall be Magnetrol, SOR, Jerguson/Magne-Sonics, or Buyer approved equal.

3.4 Temperature switches: Temperature switches, locally mounted in Division 1 or 2 locations, shall be filled system bulb type or expansion type. They shall meet the electrical classification and shall have micro switches. Separable sockets shall be furnished. Temperature switches mounted on a local panel shall normally be thermocouple actuated with cold-junction compensation and be completely adjustable. Thermowells shall be furnished for all temperature switches and shall be as specified in this Section.

3.4.1 Temperature switches shall be Ashcroft or Buyer approved Equal.

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3.5 Flow switches: Flow switches for direct operation by process fluids may be of the sight flow, rotameter, or paddle type for low accuracy requirements. Orifice plate and differential-pressure type shall be used for high accuracy requirements.

4. TEMPERATURE DEVICES:

4.1 Temperature Detectors: Temperature detectors shall be thermocouples or resistance temperature detectors (RTD) as required by the following paragraphs and the technical Specifications. All temperature detectors (thermocouple or RTD) shall be installed with a transmitter. The accuracy shall be +/- 0.4% or better.

4.1.1 Temperature detectors equipped with thermowells shall be spring-loaded and shall be furnished as complete assemblies, each including a thermowell, nipple-union-nipple, and weatherproof connection head with terminal block. Thermowells shall be as specified in this Section.

4.1.2 The cast aluminum or zinc plated cast iron head shall be approximately 4 inch (101.6 mm) in diameter with a weatherproof, screw cover that is chained to the head. The electrical connection shall be ¾ inch (19 mm) and the instrument connection shall be ½ inch (13 mm). The arrangement shall be such that rotation of the screw cover does not damage the internal components. A grounding terminal shall be provided in each connection head. The head should be "explosion-proof" rated where required for hazardous areas.

4.1.3 Thermocouples shall have ungrounded measuring junctions. The sheath shall have compacted magnesium oxide (ceramic) insulation and be made of be 304 stainless steel, 316 stainless steel, or inconel. Thermocouple assembly extensions shall be nipple union nipple type with the upper nipple the thermocouple spring loaded fitting. Extensions shall have ½ inch (13 mm) connections, be constructed of 316 stainless steel, schedule 40, and have an overall length of 6 inch (152.4 mm).

4.1.4 Thermocouples shall be ISA Type K (chromel-alumel) thermocouples with Type KX extension wire. Thermocouples and extension wire shall comply with special limits of error in accordance with the latest version of ASTM E230. Color code shall be per ISA standard for ISA thermocouple types.

4.1.5 Where the process accuracy demands or temperatures are less than 200 deg F, a resistance temperature detector may by supplied. Resistance temperature detectors shall be duplex 100-ohm 3 wire platinum, metal sheathed, ceramic packed, ungrounded resistance temperature detectors. RTDs shall be duplex.

4.1.6 Temperature elements measuring inaccessible points shall be wired out to a place safely accessible to maintenance personnel while the unit is operating. Thermocouple transmitters shall be used in lieu of long thermocouple extension wire (>250 ft / 76 m). Where thermocouple transmitters are used, they shall be installed integral to the thermocouple head and convert the signal to a 4-20 mA DC signal. Multiple temperature elements located in close proximity should

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be wired out to junction boxes and terminal strips designed for the temperature element in use, located in a place safely accessible to maintenance personnel while the unit is running. Temperature elements used for monitoring only may also be wired to transmitters. If a thermocouple or RTD is inaccessible under normal operating conditions, the leads shall be brought out to an accessible junction box and terminated on terminal blocks suited for the purpose.

4.1.7 Thermocouples/RTDs shall be Rosemount or Buyer approved equal.

4.2 Thermowells: Fluid system temperature sensors shall be equipped with stepless, tapered thermowells manufactured to ASME PTC 19.3 TW-2016 standards. Thermowells shall be made of one-piece, solid, bored construction and be designed to withstand the maximum system pressure, velocity and velocity induced vibration. Thermowells shall be constructed of the same material to match the pipe material. The bore of each well shall be concentric with the outside diameter within ±10 percent of the wall thickness. Unless otherwise indicated in the detailed Technical Specification, thermowells shall extend at least one-third (1/3) of the pipe diameter into the process stream as allowed by the ASME PTC 19.3 TW-2016 vibration analysis. The instrument tag number shall be stamped or etched on the upper hex or round portion of the thermowell. Thermowells shall have a 0.260 inch (6.604 mm) bore.

4.2.1 All thermowells in the main process lines of the Reheat System, Low Pressure Steam (excluding Auxiliary Boiler), and High Pressure Steam shall be 2 inch (50 mm) weld-in type utilizing full penetration welds. All 2 inch (50 mm) weld-in thermowells shall be installed at the pipe fabricator. The maximum unsupported length (as defined in ASME PTC 19.3 TW-2016, Fig. 6-6-1) of all weld-in thermowells shall be 2.5 inch (63.5 mm) "U" dimension. For drip legs (drain pots), the "U" dimension should be approximately 50% of the pipe ID (ASME PTC 19.3 TW-2016 calculations are not required by Seller for drip leg (drain pot) thermowells as the evaluation has already been performed).

4.2.2 Unless otherwise indicated in the detailed Technical Specification, thermowells shall be threaded or socket welded to fit the Seller's process connection. Thermowells installed in Auxiliary Steam, Boiler Feedwater System, Fuel Gas System, Compressed Gas System, and Class 600 and higher systems shall have 1½ inch (40 mm) socket weld piping connections. All other thermowells shall have 1 inch (25 mm) NPT piping connections. Threaded connections shall be constructed to allow seal welding after installation, as required. Additionally, each thermowell shall have a lagging extension equivalent to the pipe insulation thickness and have wrench flats to facilitate removal. Thermowells shall be procured from the temperature element provider.

4.3 Test Wells: Test wells shall meet all the criteria for material, design, construction, and certification specified for thermowells. Test wells shall have a 0.385 inch (9.779 mm) bore. Each test well shall be supplied with a threaded brass plug that is to be connected to the upper portion of the thermowell with a stainless steel chain. Test wells shall be procured from the temperature element provider.

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4.4 Temperature Transmitters: Primary elements for temperature service shall be temperature transmitters. The transmitters shall be microprocessor-based electronics that allow the transmitters to accept multiple types of inputs with a single set of electronics.

4.4.1 The transmitter shall output linear signals from either RTD or thermocouple inputs.

4.4.2 Transmitter shall be directly mounted to a temperature sensor or mounted in a remote location. If directly mounted to a temperature sensor then the sensor element and thermowell requirements, as noted in this specification, shall be followed. If remotely located, the transmitter shall be provided with a 2 inch (50 mm) 316 stainless steel pipe-mounting bracket and bolts. Transmitters shall be provided with dual-compartment aluminum housing.

4.4.3 Accuracy shall be at least ±0.18°F (0.1°C) ± 0.02% of span for PT 100 RTDs and at least ±0.45°F (0.25°C) ± 0.02% of span for type K thermocouples. For any temperature elements that have an element specific calibration, the associated temperature transmitter shall utilize the calibration data to increase the accuracy of the temperature measurement.

5. SOLENOID VALVES: Valves shall be selected to incorporate body construction, trim materials, and internal arrangements suitable to the application and shall be acceptable to the Buyer. Solenoid enclosures shall be NEMA 4X, unless otherwise specified. Solenoid coils shall be Class H high temperature construction and shall be suitable for continuous duty. Solenoid valves coils shall be 24VDC with Hart capabilities unless otherwise specified. Solenoid valves shall be suitable for the Area Electrical Classification, if specified.

5.1 Solenoid valves shall be mounted on the valve yokes unless specified otherwise.

5.2 When required, solenoid valves shall be three-way, connected so as to vent the top works on loss of power unless specified otherwise. Minimum process connection size shall be ¼" (6 mm) NPT.

5.3 Solenoid valves shall be by ASCO or Buyer approved equal.

6. FLOW DEVICES:

6.1 Differential Pressure Flow Elements and Restriction Orifices: Sizing calculations shall be submitted for Buyer review before manufacturing of the instrument takes place. Calculations shall be certified and conform to the requirements of ASME MFC-3M, ASME PTC 19.5, "Principles and Practices of Flow Meter Engineering" by L.K. Spinks or "Flow Measurement Engineering Handbook" by R.W. Miller. At a minimum, the calculations shall list the sizing method, process data, values of constants, permanent pressure drop, and beta ratio. Piping layouts for flow elements used for performance testing shall comply with ASME PTC-19.5. Piping layouts for flow elements not used for performance testing shall comply with ASME MFC-3M. Accuracy shall conform to ASME MFC-3M. Calibrated flow elements shall have an accuracy of +/- 1.0 perecent or better of calibrated full scale range.

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6.1.1 Orifice plates shall be constructed of 316 stainless steel as a minimum. Orifice plates shall be one-piece construction and shall be concentric, square edge, paddle type. Orifice plates used for flow measurement shall be installed between raised face, weld neck, orifice flanges. Orifice plates used for flow measurement shall have a beta ratio between 0.5 and 0.7, inclusive. The beta ratio (d/D) is defined as the ratio of the orifice diameter (d) to the inside diameter (D) of the pipe.

6.1.2 For gas and vapor service, the differential pressure range in inches of water normally shall not exceed the static absolute pressure in psia.

6.1.3 Flange taps shall normally be used in accordance with ASME B16.36, Section 9 - Pressure Taps. This applies to all piping systems regardless of pressure class.

6.1.4 The minimum orifice flange rating shall be ANSI Class 300. The use of higher rated flanges, or of facing type, shall be as called for in piping specifications.

6.1.5 Ring-type plate holders shall be manufacturer's standard plate mounting. Ring facing shall be oval ANSI standard unless otherwise required by piping specifications.

6.1.6 Flow element pressure taps for horizontal pipe runs shall normally be oriented horizontal for clean liquids and steam, and vertical-up for dry gases. Flow orifice plates shall be installed only after applicable piping has been flushed or blown down.

6.1.7 Venturi tubes, low-loss tubes, and flow nozzles shall be used where high-pressure recovery is necessary and/or where only low inlet pressure is available.

6.1.8 Integral orifice meters (combination primary element-measuring device) shall normally be used for meter runs of less than 1½ inch (40 mm) with a suitable strainer upstream of the meter. This type of flow meter shall not be used in outdoor installations where there is a risk of freezing temperatures.

6.1.9 Eccentric type orifice plates shall be used for fluids containing two phases. The eccentric-type orifice plates shall have the bottom of the orifice bore flush with the bottom ID of the pipe. Eccentric orifice plates shall be used only in horizontal runs.

6.1.10 Orifice, flow nozzles and venturis shall be Fluidic Technologies, Triad, Primary Flow Signals (PFS), or Buyer approved equal.

6.2 Other types of flow elements should be considered for non-critical services where their use is desirable and the above-mentioned elements are not applicable. Piping layouts shall be per manufacturer’s standard.

6.2.1 Averaging pitot tubes may be used where the pipe diameter is too large for acceptable orifice plate design in applications such as pump minimum flow bypass control, or

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where normal straight pipe requirements are not met. Pitot tubes shall be constructed of stainless steel material as a minimum.

6.2.2 Acceptable vendors are Dieterich Standard, Deltabar/Mid-West Instrument, Veris, or Buyer approved equal.

6.2.3 Magnetic flow meters shall be used in applications where the conventional flow instruments cannot be used or are not suitable (e.g., slurry applications).

6.2.4 Rotameters shall be used for local indication on low flows. Process rotameters shall have metal tubes. Glass tube rotameters shall only be used for purging or auxiliary service with non-hazardous fluids.

7. INSTRUMENT VALVE MANIFOLDS: Each remotely mounted instrument shall be provided with instrument valve manifold assembled at the factory as specified below.

7.1 Instrument Manifold Valves: Instrument manifold valves shall be provided as follows:

7.1.1 Instruments with one (1) process connection shall be fitted with a 2 valve manifold.

7.1.2 Instruments with two (2) process connections shall be fitted with a 5 valve manifold.

7.1.3 A Male Connector, Swagelok SS-810-1-4 or Buyer Approved Equivalent, shall be provided and be shop installed in each vent port of the manifold.

8. INSTRUMENT INSTALLATION: All instrument, control, and sampling tubing installed by the Vendor shall be pressure tested for leaks. All tubing shall be 316 stainless steel grade ASTM 213 or better with a minimum average wall thickness of 0.065 inch (1.245 mm) (or larger to meet max working pressure requirements). All tubing fittings shall be Swagelok or Buyer approved equal.

8.1 Temperature, pressure, and differential-pressure transmitters, switches, and transducers shall be mounted on either stands or racks or in local instrument cabinets as long as instruments are properly protected, including environmental protection (heat traced). Instruments that can be logically grouped shall be installed on racks or in local instrument cabinets. Instrumentation, accessories, and all other equipment shall be located and mounted such that calibration, maintenance, and removal work can be performed on any one piece of equipment without disturbing another. Adequate clearance shall be provided so that calibration, adjustments, and connections are easily accessible without need of instrument removal. All instrument covers shall be provided with adequate clearance space for removal. Equipment shall be arranged such that work can be performed easily, without need for special tools.

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8.2 Instruments, instrument valves, and manifold valves shall be easily accessible for calibration.

8.3 Each pressure connection, except for relief valves, shall have a root valve.

8.4 All external electrical connections of junction boxes and cabinets shall be made to terminal blocks. The wiring and terminal blocks for different voltage classes shall be physically separated in order to minimize electrical noise and hazard to personnel. Terminal blocks shall be provided with marker strips.

8.5 Instruments shall be mounted in a manner that prevents vibration effects. Where necessary, pulsation dampeners shall be supplied.

8.6 Instrumentation installation shall be designed for proper sensing of process variables. Taps on process lines shall be located such that sensing lines do not trap air in liquid service or liquid in gas service. Calibration tees shall be provided for all instruments requiring calibration. In general, impulse lines measuring liquids shall be connected to the process piping at an angle between horizontal and 45° down from horizontal. In general, impulse lines measuring vapors, gas and air shall be connected to the process piping at an angle between vertical and 90° down from vertical. The height of the parallel legs of differential pressure elements must be identical and shall emanate from the same side of the pipe to facilitate the connection of winterization tubing bundles. The process connection shall be located to allow for correct orientation of the instruments while maintaining accessibility. Instruments measuring the pressure or flow of steam or liquids or measuring levels shall be located below the process connections. Instruments measuring the pressure or flow of vapors, gas or air shall be mounted above the process connections. Impulse lines connected to steam or hot water services shall be of sufficient length to allow for cooling of the liquids before they come into contact with the transmitter cell.

8.7 Sample tubing connection shall be ½ inch (13 mm) minimum nominal diameter.

8.8 Pressure transmitters, switches, etc. connected to steam lines shall be remote mounted. Inline instruments, including analyzers, shall be removable from the line for servicing without requiring a unit shutdown.

8.9 Sample tubing systems carrying high temperature samples shall be insulated in areas that require personnel protection. Personnel burn protection limit shall be at 140 °F (60 °C) sustained.

9. HEATED INSTRUMENT ENCLOSURES: Where applicable, the instrumentation's interface with the process shall be capable of being thermally insulated and heat traced to prevent freezing without damage or obstruction of instrument operation, readouts, or displays. All instruments installed outdoors shall be installed in heated enclosures as required. Buyer shall coordinate with Seller to ship furnished instruments to a third party to be installed in heated enclosures. All instruments that require a heated enclosure must be approved by the Buyer.

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10. HEAT TRACING: Drawings shall indicate the equipment, piping, tubing, and instruments that may freeze, become viscous, or have undesirable condensation/precipitation/hydrate formation that will require heat tracing for freeze protection.

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END OF SECTION

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