

SECTION 40 91 00
INSTRUMENTATION AND CONTROL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

- A. This section gives general requirements for instrumentation and control components.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. American Iron and Steel Institute (AISI).
 - 2. ASTM International (ASTM):
 - a. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
 - b. A276, Standard Specification for Stainless Steel Bars and Shapes
 - c. A312/A312M, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
 - d. B32, Standard Specification for Solder Metal.
 - e. B88, Standard Specification for Seamless Copper Water Tube.
 - 3. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.03 SUBMITTALS

- A. Refer to Section 40 90 00, Instrumentation and Control for Process Systems, Article Submittals for the requirements of the action and informational submittals.

PART 2 PRODUCTS

2.01 GENERAL

- A. Article Mechanical Systems Components covers requirements of mechanical PIC components that are not specifically referenced by Section 40 90 00, Instrumentation and Control for Process Systems, Instrument Lists or Data Sheets.

- B. Article Electrical Components covers requirements for electrical PIC components that are not specifically referenced by Section 40 90 00, Instrumentation and Control for Process Systems, Instrument Lists or Data Sheets.
- C. All other Part 2 articles cover components that are referenced by Instrument Lists or Data Sheets in Section 40 90 00, Instrumentation and Control for Process Systems, or by specific component numbers in other PIC subsections.
- D. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.
 - 1. Use or reuse of components and materials without a traceable certification is prohibited.
- E. Items designated as stainless steel shall be AISI Type 304, unless otherwise noted. Items designated as Type 316 shall meet AISI Type 316.

2.02 MECHANICAL SYSTEMS COMPONENTS

- A. Flow Element, Rotameter, Purge:
 - 1. Physical Characteristics:
 - a. For air or water service, unless otherwise noted.
 - b. Materials: Glass tube, fiberglass body, stainless steel float, nylon ball check valve.
 - 2. Functional Characteristics:
 - a. Integral inlet needle valves.
 - b. Integral Differential Pressure Regulators:
 - 1) For water service.
 - 2) For air service for level ranges greater than 10 feet of water.
 - 3. Performance Characteristics:
 - a. Direct-Reading Scale Length: 2-1/2 inches, minimum.
 - b. Scale Ranges: 0 scfh to 2.5 scfh for air service or 0 gph to 10 gph for water service.
- B. Manifold, Three-Valve Equalizing:
 - 1. Physical Characteristics:
 - a. For isolation and equalization of differential pressure transducers.
 - b. Materials: Stainless steel.

2. Functional Characteristics: None.
 3. Performance Characteristics: None.
- C. Pressure Gauge: For other than process variable measurement.
1. Physical Characteristics:
 - a. Dial Size: Nominal 2-inch dial size.
 - b. Connection: 1/4-inch NPT through bottom, unless otherwise noted.
 2. Function Characteristics: None.
 3. Performance Characteristics:
 - a. Accuracy: 2 percent of span.
 - b. Scale Range: Such that normal operating pressure lies between 50 percent and 80 percent of scale range.
- D. Valve, Needle:
1. Physical Characteristics:
 - a. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by manufacturer for designated service, unless otherwise shown on the Drawings.
 - b. Size: 0.020-inch orifice.
 2. Functional Characteristics: None.
 3. Performance Characteristics: None.
- E. ON/OFF Valves:
1. Physical Characteristics:
 - a. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by manufacturer for designated service, unless otherwise shown on the Drawings.
 2. Functional Characteristics: Ball valve.
 3. Performance Characteristics: None.
- F. Regulating Valves:
1. Physical Characteristics:
 - a. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by manufacturer for designated service, unless otherwise shown on the Drawings.
 2. Functional Characteristics: Needle valves, with regulating stems and screwed bonnets.
 3. Performance Characteristics: None.

G. Valve, Three-Way:

1. Physical Characteristics:
 - a. Materials: Brass or stainless steel with nylon handle as recommended by manufacturer for designated service, unless otherwise shown on the Drawings.
2. Functional Characteristics: Ball valve.
3. Performance Characteristics: None.

H. Valve, Four-Way:

1. Physical Characteristics:
 - a. Materials:
 - 1) Body and Stem: Type 316 stainless steel.
 - 2) Handle: Black nylon.
 - 3) Packing Gland: Polytetrafluoroethylene (PTFE).
 - b. Ball and stem bed, one-piece assembly.
 - c. Machined handle stops and directional nameplates.
2. Functional Characteristics: Four-way, two-position ball valve.
3. Performance Characteristics: None.

I. Spool Valve:

1. Physical Characteristics:
 - a. Materials: Aluminum construction with polytetrafluoroethylene (PTFE) impregnated aluminum spool, stainless steel spring, and nitrile rubber O-rings.
 - b. Port Connection: 1/4-inch outside diameter tube fittings.
2. Functional Characteristics: Five-port arrangement as shown, two-position, push-to-operate knob attached to the spool stem, and spring return.
3. Performance Characteristics: None.

J. Solenoid Valve, Two-Way:

1. Physical Characteristics:
 - a. Materials:
 - 1) Body: Brass or stainless steel globe valves as recommended by manufacturer for designated service, unless otherwise shown on the Drawings.
 - 2) Valve Seat: Nitrile rubber.
 - b. Size: Normally closed or opened, as noted.
 - c. Coil: 115V ac, unless noted otherwise.
 - d. Solenoid Enclosure: NEMA 4.
2. Functional Characteristics: Globe valve directly actuated by solenoid and not requiring minimum pressure differential for operation.
3. Performance Characteristics: None.

K. Pressure Regulator, Air:

1. Physical Characteristics:
 - a. Provide air at reduced pressures, as shown, constant to within plus or minus 10 percent for flows from 0 scfh to 300 scfh with 100 psi supply pressure.
 - b. Setscrew for outlet pressure adjustment.
 - c. Integral filter and relief valve.
2. Functional Characteristics: None.
3. Performance Characteristics: None.

L. Pressure Regulator, Water:

1. Physical Characteristics:
 - a. Materials:
 - 1) Body: Bronze.
 - 2) Spring Case: Cast iron.
 - 3) Seat Rings: Brass.
 - 4) Valve Disk and Holder: Nitrile rubber and bronze.
 - 5) Diaphragm: Nitrile rubber diaphragm.
2. Functional Characteristics: None.
3. Performance Characteristics: None.

M. Copper Tubing and Fittings:

1. Physical Characteristics:
 - a. Type K hard copper, ASTM B88, with commercially pure wrought copper solder joint fittings. Make joints with 95-5 wire solder, ASTM B32, Grade 95 TA. Do not use cored solder.
 - b. Alternatively, Type K, soft temper copper tubing, ASTM B88, with brass compression type fittings may be used where shown on the Drawings.
2. Functional Characteristics: None.
3. Performance Characteristics: None.

N. Plastic Tubing and Fittings:

1. Physical Characteristics:
 - a. Tubing: Polyethylene capable of withstanding 190 psig at 175 degrees F.
 - b. Fittings:
 - 1) Type: Brass compression.
2. Functional Characteristics: None.
3. Performance Characteristics: None.

O. Stainless Steel Tubing: ASTM A312/A312M, Type 316, 0.065-inch wall, seamless, soft annealed, as shown on the Drawings.

P. Stainless Steel Fittings:

1. Physical Characteristics:
 - a. Compression Type:
 - 1) Materials: Type 316 stainless steel, ASTM A182/A182M forged bodies or ASTM A276 barstock bodies, flareless.
 - b. Socket Weld Type:
 - 1) Materials: Type 316 stainless steel, ASTM A182/A182M forged bodies or ASTM A276 barstock bodies, 3,000 psi maximum working pressure, safety factor 4:1.
2. Functional Characteristics: None.
3. Performance Characteristics: None.

2.03 ELECTRICAL COMPONENTS

A. Terminal Blocks for Enclosures:

1. General:
 - a. Physical Characteristics:
 - 1) Connection Type: Screw compression clamp.
 - 2) Compression Clamp:
 - a) Complies with DIN-VDE 0611.
 - b) Hardened steel clamp with transversal grooves that penetrate wire strands providing a vibration-proof connection.
 - c) Guides strands of wire into terminal.
 - 3) Screws: Hardened steel, captive, and self-locking.
 - 4) Current Bar: Copper or treated brass.
 - 5) Mounting:
 - a) Standard DIN rail.
 - b) Terminal block can be extracted from an assembly without displacing adjacent blocks.
 - c) End Stops: Minimum of one at each end of rail.
 - 6) Wire Preparation: Stripping only permitted.
 - 7) Jumpers: Allow jumper installation without loss of space on terminal or rail.
 - 8) Marking System:
 - a) Terminal number shown on both sides of terminal block.
 - b) Allow use of preprinted and field marked tags.
 - c) Terminal strip numbers shown on end stops.
 - d) Mark terminal block and terminal strip numbers as shown on panel control diagrams and loop diagrams.
 - e) Fuse Marking for Fused Terminal Blocks: Fuse voltage and amperage rating shown on top of terminal block.

- 9) Test Plugs: Soldered connections for 18 AWG wire.
 - a) Pin Diameter: 0.079 inch.
 - b) Quantity: Two plugs per test meter.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics:
 - 1) Insulation:
 - a) Thermoplastic rated for minus 55 degrees C to plus 110 degrees C.
 - b) Two funneled shaped inputs to facilitate wire entry.
 2. Terminal Block, General Purpose:
 - a. Physical Characteristics:
 - 1) Wire Size: 24 AWG to 10 AWG.
 - 2) Rated Wire Size: 10 AWG.
 - 3) Color: Gray body.
 - 4) Spacing: 0.25 inch, maximum.
 - 5) Test Sockets: One screw test socket 0.079-inch diameter.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics:
 - 1) Rated Voltage: 600V ac.
 - 2) Rated Current: 30 amp.
 3. Terminal Block, Ground:
 - a. Physical Characteristics:
 - 1) Wire Size: 24 AWG to 10 AWG.
 - 2) Rated Wire Size: 10 AWG.
 - 3) Color: Green and yellow body.
 - 4) Spacing: 0.25 inch, maximum.
 - 5) Grounding: Electrically grounded to mounting rail.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.
 4. Terminal Block, Blade Disconnect Switch:
 - a. Physical Characteristics:
 - 1) Wire Size: 22 AWG to 10 AWG.
 - 2) Rated Wire Size: 10 AWG.
 - 3) Color: Gray body, orange switch.
 - 4) Spacing: 0.25 inch, maximum.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics:
 - 1) Rated Voltage: 600V ac.
 - 2) Rated Current: 10 amp.
 5. Terminal Block Diode:
 - a. Physical Characteristics:
 - 1) Wire Size: 16 AWG.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics:
 - 1) Rated Voltage: 24V dc.
 - 2) Rated Current: 30 mA.

6. Terminal Block, Fused, 24V dc:
 - a. Physical Characteristics:
 - 1) Wire Size: 22 AWG to 10 AWG.
 - 2) Rated Wire Size: 10 AWG.
 - 3) Color: Gray body.
 - 4) Fuse: 0.25 inch by 1.25 inches.
 - 5) Indication: LED diode 24V dc.
 - 6) Spacing: 0.512 inch, maximum.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics:
 - 1) Rated Voltage: 600V dc.
 - 2) Rated Current: 25 amp.
7. Terminal Block, Fused, 120V ac:
 - a. Physical Characteristics:
 - 1) Wire Size: 22 AWG to 10 AWG.
 - 2) Rated Wire Size: 10 AWG.
 - 3) Color: Gray body.
 - 4) Fuse: 0.25 inch by 1.25 inches.
 - 5) Indication: Neon lamp, 110V ac.
 - 6) Leakage Current: 1.8 mA, maximum.
 - 7) Spacing: 0.512 inch, maximum.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics:
 - 1) Rated Voltage: 600V ac.
 - 2) Rated Current: 25 amp.
8. Terminal Block, Fused, 120V ac, High Current:
 - a. Physical Characteristics:
 - 1) Wire Size: 18 AWG to 8 AWG.
 - 2) Rated Wire Size: 8 AWG.
 - 3) Color: Gray.
 - 4) Fuse: 13/32 inch by 1.5 inches.
 - 5) Spacing: 0.95 inch, maximum.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics:
 - 1) Rated Voltage: 600V ac.
 - 2) Rated Current: 35 amps.

B. Relays:

1. General:
 - a. Physical Characteristics:
 - 1) Relay Mounting: Plug-in type socket.
 - 2) Relay Enclosure: Furnish dust cover.
 - 3) Socket Type: Screw terminal interface with wiring.
 - 4) Socket Mounting: Rail.
 - 5) Provide holddown clips.

- b. Functional Characteristics: None.
 - c. Performance Characteristics: None.
- 2. Signal Switching Relay:
 - a. Physical Characteristics:
 - 1) Type: Dry circuit.
 - 2) Contact Arrangement: 2 Form C contacts.
 - 3) Contact Rating: 5 amps at 28V dc or 120V ac.
 - 4) Contact Material: Gold or silver.
 - 5) Indication Type: Neon or LED indicator lamp.
 - 6) Seal Type: Hermetically sealed case.
 - b. Functional Characteristics:
 - 1) Expected Mechanical Life: 10,000,000 operations.
 - 2) Expected Electrical Life at Rated Load: 100,000 operations.
 - c. Performance Characteristics:
 - 1) Coil Voltage: As noted or shown.
 - 2) Coil Power: 0.9 watt dc, 1.2VA ac.
- 3. Control Circuit Switching Relay, Nonlatching:
 - a. Physical Characteristics:
 - 1) Type: Compact general purpose plug-in.
 - 2) Contact Arrangement: 3 Form C contacts.
 - 3) Contact Material: Silver cadmium oxide alloy.
 - 4) Indication Type: Neon or LED indicator lamp.
 - b. Functional Characteristics:
 - 1) Push-to-test button.
 - 2) Expected Mechanical Life: 10,000,000 operations.
 - 3) Expected Electrical Life at Rated Load: 100,000 operations.
 - c. Performance Characteristics:
 - 1) Contact Rating: 10A at 28V dc or 120V ac, and 6.6A at 240V ac.
 - 2) Coil Voltage: As noted or shown.
 - 3) Coil Power: 1.8 watts dc, 2.7VA ac.
- 4. Control Circuit Switching Relay, Latching:
 - a. Physical Characteristics:
 - 1) Type: Dual coil mechanical latching relay.
 - 2) Contact Arrangement: 2 Form C contacts.
 - 3) Contact Rating: 10A at 28V dc or 120V ac.
 - 4) Contact Material: Silver cadmium oxide alloy.
 - b. Functional Characteristics:
 - 1) Expected Mechanical Life: 500,000 operations.
 - 2) Expected Electrical Life at Rated Load: 50,000 operations.
 - c. Performance Characteristics:
 - 1) Coil Voltage: As noted or shown.
 - 2) Coil Power: 2.7 watts dc, 5.3VA ac.

5. Control Circuit Switching Relay, Time Delay:
 - a. Physical Characteristics:
 - 1) Type: Adjustable time delay relay.
 - 2) Contact Arrangement: 2 Form C contacts.
 - 3) Contact Material: Silver cadmium oxide alloy.
 - 4) Adjustment Type: Integral potentiometer with knob external to dust cover.
 - b. Functional Characteristics:
 - 1) Delay Time Range: Select range such that time delay setpoint fall between 20 percent to 80 percent of range.
 - 2) Time Delay Setpoint: As noted or shown.
 - 3) Mode of Operation: As noted or shown.
 - c. Performance Characteristics:
 - 1) Repeatability: Plus or minus 2 percent.
 - 2) Operating Temperature: Minus 10 degrees C to 55 degrees C.
 - 3) Coil Voltage: As noted or shown.
 - 4) Contact Rating: 10A at 30V dc or 277V ac.

C. Surge Suppressors:

1. General:
 - a. Physical Characteristics:
 - 1) Construction: First-stage, high-energy metal oxide varistor and second-stage, bipolar silicon avalanche device separated by series impedance; includes grounding wire, stud, or terminal.
 - 2) Enclosure Mounted: Encapsulated inflame retardant epoxy.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics:
 - 1) Response: 5 nanoseconds maximum.
 - 2) Recovery: Automatic.
 - 3) Temperature Range: Minus 20 degrees C to plus 85 degrees C.
2. Suppressors on 120V ac Power Supply Connections:
 - a. Physical Characteristics:
 - 1) First-Stage Clamping Voltage: 350 volts or less.
 - 2) Second-Stage Clamping Voltage: 210 volts or less.
 - 3) Power Supplies for Continuous Operation:
 - a) Four-Wire Transmitter or Receiver: Minimum 5 amps at 130V ac.
 - b) All Other Applications: Minimum 30 amps at 130V ac.
 - b. Functional Characteristics: None.

- c. Performance Characteristics:
 - 1) Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE C62.41 Category B test waveform.
 - 3. Suppressors on Analog Signal Lines:
 - a. Physical Characteristics:
 - 1) Test Waveform: Linear 8-microsecond rise in current from 0 amps to a peak current value followed by an exponential decay of current reaching one-half the peak value in 20 microseconds.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics:
 - 1) Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
 - a) dc Clamping Voltage: 20 percent to 40 percent above operating voltage for circuit.
 - b) dc Clamping Voltage Tolerance: Plus or minus 10 percent.
 - c) Maximum Loop Resistance: 18 ohms per conductor.
- D. Maintenance Bypass Switches:
 - 1. Physical Characteristics:
 - a. Hand switch for mode toggle, UPS/Bypass.
 - b. Power distribution unit, four or more outlets.
 - c. Mounting: 19-inch rack mount, or wall mount.
 - 2. Functional Characteristics:
 - a. Hot-swap maintenance bypass switch that will completely isolate power from the UPS without interruption of power to the loads being served.
 - 3. Performance Characteristics:
 - a. Input Power: 120V ac, single phase, three-wire, 60-Hz, unless otherwise noted.
 - b. Output Power: 120V ac, single phase, three-wire, 60-Hz, unless otherwise noted.
 - c. Operating Temperature: 0 degree C to 60 degrees C (32 degrees F to 140 degrees F).
- E. Power Supplies:
 - 1. Physical Characteristics:
 - a. Furnish as required to power instruments requiring external dc power, including two-wire transmitters and dc relays. Provide dual power supplies with diode auctioneered outputs.
 - b. Enclosures: NEMA 1.
 - c. Mount such that dissipated heat does not adversely affect other components.

2. Functional Characteristics:
 - a. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
 - b. Provide output over voltage and over current protective devices to:
 - 1) Protect instruments from damage due to power supply failure.
 - 2) Protect power supply from damage due to external failure.
3. Performance Characteristics:
 - a. Fuses: For each dc supply line to each individual two-wire transmitter.
 - 1) Type: Indicating.
 - 2) Mount so fuses can be easily seen and replaced.

F. Intrinsic Safety Barriers:

1. Physical Characteristics: None.
2. Functional Characteristics:
 - a. Intrinsically Safe Relays: Monitor discrete signals that originate in hazardous area and are used in a safe area.
 - b. Intrinsically Safe Barriers: Interface analog signals as they pass from hazardous area to safe area.
3. Performance Characteristics: None.

2.04 I&C FIELD COMPONENTS

A. A00 Analyzer/Transmitter:

1. Manufacturers and Products:
 - a. Hach; SC1000 Controllers.
 - b. Or equal.
2. Physical Characteristics:
 - a. Display:
 - 1) VGA Graphic Backlit TFT color Touch Screen.
 - 2) Display all elements and each of their signals.
 - b. Sensors:
 - 1) Sensor Connections: Up to 12.
 - c. Signal Interface:
 - 1) Analog Outputs: Up to 12 isolated 4 mA dc to 20 mA signals.
 - 2) Discrete Outputs: Up to 4 SPDT, 5 amps.
 - d. Enclosure:
 - 1) Type: NEMA 4X.
 - 2) Power: 115V ac, 50/60-Hz unless otherwise noted.

3. Functional Characteristics: Measure, indicate, and transmit multiple elements.
4. Performance Characteristics:
 - a. Operating Temperature: Minus 4 degrees F to plus 131 degrees F.
 - b. Operating Humidity: 95 percent; relative humidity (noncondensing).

B. A01 Analyzer/Transmitter:

1. Manufacturers and Products:
 - a. Hach; SC200 Controllers.
 - b. Or equal.
2. Physical Characteristics:
 - a. Display: Graphic dot Matrix with LED backlighting.
 - b. Sensors:
 - 1) Sensor Connections: 2.
 - c. Signal Interface:
 - 1) Analog Outputs: 2 isolated 4 mA dc to 20 mA signals.
 - 2) Discrete Outputs: 4 SPDT, 5 amps.
 - d. Enclosure:
 - 1) Type: NEMA 4X.
 - 2) Power: 115V ac, 50/60-Hz unless otherwise noted.
3. Functional Characteristics: Measure, indicate, and transmit multiple elements.
4. Performance Characteristics:
 - a. Operating Temperature: Minus 4 degrees F to plus 140 degrees F.
 - b. Operating Humidity: 95 percent; relative humidity (noncondensing).

C. A05 ORP Element and Transmitter:

1. Manufacturers and Products:
 - a. Hach; DRD1P5.
 - b. Or equal.
2. Physical Characteristics:
 - a. Process Connection: 1-inch MNPT.
 - b. Body Style: Convertible with 1-inch NPT on both ends.
 - c. Wetted Materials: Compatible with process fluid.
 - d. No field-replaceable parts, unless otherwise noted.
 - e. Electrode Type: Flat glass or general purpose, unless otherwise noted.
 - f. Integral Preamplifier: Required, unless otherwise noted.
 - g. Mounting/Process Connections:
 - 1) As shown on the Drawings or as noted from among the following:
 - a) Union mounting kit for 1 1/2-inch" NPT tee.

- h. Interconnecting Cable: Length as required.
- i. Accessories:
 - 1) Junction Box: If noted.
 - a) NEMA 4X box for cable extension.
- 3. Functional Characteristics: None.
- 4. Performance Characteristic:
 - a. Measurement: 1500 mV to plus 1500 mV.
 - b. Type: Digital Differential.
 - c. Process Fluid: As Noted.
 - d. Operating Temperature: 32 degrees F to 185 degrees F.
 - e. Operating Pressure: 100 psig maximum at 149 degrees F.
 - f. Suitable for installation in Class I, Division 2 hazardous locations:
 - If noted or shown.
 - 1) Install in accordance with manufacturer's instructions and applicable codes.

D. A07 pH Element and Transmitter:

- 1. Manufacturers and Products:
 - a. Hach; DPD1P1.
 - b. Or equal.
- 2. Physical Characteristics:
 - a. Process Connection: 1-inch MNPT.
 - b. Body Style: Convertible with 1-inch NPT on both ends.
 - c. Wetted Materials: Compatible with process fluid.
 - d. No field-replaceable parts, unless otherwise noted.
 - e. Electrode Type: Flat glass or general purpose, unless otherwise noted.
 - f. Integral Preamplifier: Required, unless otherwise noted.
 - g. Mounting/Process Connections:
 - 1) As shown on the Drawings or as noted from among the following:
 - a) Union mounting kit for 1 1/2-inch NPT tee.
 - h. Interconnecting Cable: Length as required.
 - i. Accessories:
 - 1) Expendables (for each unit provided):
 - a) Chemicals: 1 pint each of buffer solution for pH 4, pH 7, and pH 9.
 - 2) Junction Box: NEMA 4X Box for Cable Extension.
- 3. Functional Characteristics: Measure pH of process fluid.
- 4. Performance Characteristics:
 - a. Element:
 - 1) Measurement: 0 pH to 14 pH.
 - 2) Type: Digital differential.
 - 3) Process Fluid: As noted.
 - 4) Operating Temperature: 23 degrees F to 203 degrees F.

- 5) Operating Pressure: 100 psig maximum at 221 degrees F.
- 6) Suitable for installation in Class I, Division 2 hazardous locations: If noted or shown.
 - a) Install in accordance with manufacturer's instructions and applicable codes.
- 7) Shall meet EPA Method 150.3 requirements.

E. A09 Turbidimeter Element:

1. Manufacturers and Products:
 - a. HACH; TU5300sc.
 - b. Or equal.
2. Physical Characteristics:
 - a. Panel mounted.
 - b. Sample flow range: 100 ml/min to 1,000 mL/min.
 - c. Sample inlet and sample drain connection: 1/4-inch OD tubing.
 - d. Cable Length: 5 feet.
3. Functional Characteristics:
 - a. Membrane equipment system, continuous monitoring of turbidity to identify loss of membrane integrity.
 - b. Membrane equipment system, continuous monitoring of turbidity to identify loss of membrane system performance.
 - c. Light Source: Class 2 laser product, with embedded 650 nm (EPA) or 850 nm (ISO), max. 1.0 mW Class 2 laser source.
4. Performance Characteristics:
 - a. Range: 0 NTU to 40 NTU.
 - b. Sample Temperature Range: 2 degrees C to 60 degrees C.
 - c. Accuracy: Plus or minus 2 percent or 0.01 NTU from 0 NTU to 40 NTU.
 - d. Repeatability: Better than 1 percent of reading or Plus or minus 0.002 NTU (TU5300sc).
 - e. Resolution: 0.0001 NTU.
 - f. Response Time: Less than 45 seconds at 100 mL/min.

F. A10 Combustible Gas Element and Transmitter:

1. Manufacturers and Products:
 - a. MSA; Ultima X5000 Gas Monitor.
 - b. Or equal.
2. Physical Characteristics:
 - a. Sensor Type: Infrared, unless otherwise noted.
 - b. Sensor mounted remotely from transmitter, unless otherwise noted.
 - c. LCD Display.
 - d. Nonintrusive interface for functional, calibration, and alarm testing.

- e. Enclosure:
 - 1) Transmitter:
 - a) Explosion proof, suitable for Class 1, Division 1, Group C and Group D; unless otherwise noted.
 - b) NEMA 4X, Type 316 stainless steel.
 - c) Minimum of four-wire entry holes.
 - 2) Sensor Junction Box:
 - a) Explosion proof, suitable for Class 1, Division 1, Group C and Group D; unless otherwise noted.
 - b) NEMA 4X, Type 316 stainless steel.
 - c) Minimum of four-wire entry holes.
- f. Input Power: 24V dc.
- g. Signal Interface:
 - 1) Three SPDT relays rated for 230V ac at 5 amps resistive.
 - a) Configured for warning and alarm levels, and unit fault.
 - 2) Analog Output: 4 mA dc to 20 mA dc analog output capable of driving 600 ohms at 24V dc.
- 3. Functional Characteristics: Continuously monitor ambient air for lower explosive limit (LEL) of combustible hydrocarbon based gases.
- 4. Performance Characteristics:
 - a. Range:
 - 1) Methane: 0 percent to 100 percent LEL.
 - 2) Hexane: 0 percent to 100 percent LEL.
 - b. Repeatability: Plus or minus 2 percent of full scale.
 - c. Long Term Drift (6 Months): Less than plus or minus 1 percent LEL.
 - d. Response Time, t90: Less than 15 seconds.
 - e. Temperature, Operating: Minus 22 degrees F to 131 degrees F.
 - f. Humidity, Operating: 5 percent to 95 percent relative humidity, noncondensing.

G. A20 Dissolved Oxygen Element, Nonmembrane Luminescent (LDO):

- 1. Manufacturers and Products:
 - a. Hach; LDO.
 - b. Or equal.
- 2. Physical Characteristics:
 - a. Type: Luminescent or fluorescence sensor.
 - b. Submersion Depth: 350 feet maximum.
 - c. Mounting/Process Connections:
 - 1) As shown on the Drawings or as noted from among the following:
 - a) Union mounting kit for 2-inch NPT tee.
 - d. Sensor Cable: Integral 33 feet of cable. Provide additional length as required.

- e. Junction Box: Provide junction or termination box and extension cable as required.
- f. Mounting: 1-1/2 UNF – 12 UNF thread.
- 3. Functional Characteristics: Continuous measurement of dissolved oxygen (DO) concentration of process fluid.
- 4. Performance Characteristics:
 - a. Range: 0 ppm to 20 ppm.
 - b. Sensor Accuracy:
 - 1) Measurement: Plus or minus 0.2 percent of span.
 - 2) Temperature: Plus or minus 0.2 degree C.
 - c. Response Time: Less than 40 seconds to 90 percent of value upon step change.
 - d. Process Temperature Range: 32 degrees F to 122 degrees F.

H. A29 Free Chlorine Residual Analyzer:

- 1. Manufacturers and Products:
 - a. Element:
 - 1) Hach; CLF10sc.
 - 2) Or equal.
- 2. Physical Characteristics:
 - a. Element:
 - 1) Process Connections:
 - a) Sample Inlet: 1/4 inch or 1/2 inch.
 - b) Drain Connections:
 - (1) Maximum of two.
 - (2) Between 1/4 inch and 1-1/4 inches.
- 3. Functional Characteristics: Measure and indicate total residual chlorine of sample.
- 4. Performance Characteristics:
 - a. Element:
 - 1) Measurement: Free residual chlorine.
 - 2) Type: Liquid or gas phase amperometric.
 - 3) Process Range: As noted.
 - 4) Sample Flow:
 - a) Through Unit: 10.5 gallons per hour nominal.
 - 5) Sample Inlet Pressure: 50 psig maximum.
 - 6) Sample Temperature Range: 41 degrees F to 113 degrees F.
 - 7) Sample Acceptable Water Quality Ranges:
 - a) pH: 4 to 9.

I. A35A Total Suspended Solids Element; Retractable Mount:

- 1. Manufacturers and Products:
 - a. Hach; TSS XL sc.
 - b. Or equal.

2. Physical Characteristics:
 - a. Type: Light scatter detection measurement using a 90-degree scatter photocell detector.
 - b. Mounting Options:
 - 1) Ball valve armature including non coped carbon steel welding flange.
 - c. Material: Stainless Steel.
 - d. Cable Length: 10 m.
3. Functional Characteristics: Continuously measure, indicate, and transmit a signal proportional to total suspended solids.
4. Performance Characteristics:
 - a. Range: 0 mg/L to 50.0 mg/L.
 - b. Repeatability: Less than 3 percent.
 - c. Process Temperature: 0 degree C to 40 degrees C.

J. A35B Total Suspended Solids Element; Triclamp Mount:

1. Manufacturers and Products:
 - a. Hach; TSS XL sc.
 - b. Or equal.
2. Physical Characteristics:
 - a. Type: Light scatter detection measurement using a 90-degree scatter photocell detector.
 - b. Mounting Options: Triclamp onto a stainless steel weld-on fitting for a 3-inch pipe.
 - c. Material: Stainless steel.
 - d. Cable Length: 10 m.
3. Functional Characteristics: Continuously measure, indicate, and transmit a signal proportional to total suspended solids.
4. Performance Characteristics:
 - a. Range: 0 mg/L to 50.0 mg/L.
 - b. Repeatability: Less than 3 percent.
 - c. Process Temperature: 0 degree C to 40 degrees C.

K. A46 NO3 Element:

1. Manufacturers and Products:
 - a. Hach; N-SIE Nitrate Probe.
 - b. Or equal.
2. Physical Characteristics:
 - a. Process Connection: 1-inch MNPT on back end.
 - b. Wetted Materials: Stainless Steel.
 - c. Electrode Type: Ion-selective electrodes (ISE).

- d. Mounting/Process Connections:
 - 1) As shown on the Drawings or as noted from among the following:
 - a) Submersion: Sensor handrail assembly.
 - e. Interconnecting Cable: Length as required.
 - 3. Functional Characteristics: Measure, indicate, and transmit NO3 of process fluid.
 - 4. Performance Characteristic:
 - 1) Range: 0 mg/L to 1,000 mg/L NO3.
 - 2) Operating Temperature: Minus 4 degrees F to 113 degrees F.
 - 3) Repeatability: Plus or minus 5 percent.
- L. F04 Flow Element and Transmitter, Electromagnetic:
 - 1. Manufacturers and Products:
 - a. Endress + Hauser, Promag W 400.
 - b. Or equal.
 - 2. Physical Characteristics:
 - a. Element:
 - 1) Process Connection:
 - a) Meter Size (diameter inches): As noted.
 - b) Connection Type: 150-pound ANSI raised-face flanges; AWWA C207, Table 2 Class D; or wafer style depending on meter size, unless otherwise noted.
 - c) Flange Material: Carbon steel, unless otherwise noted.
 - 2) Meter Tube Material: Type 304 or Type 316 stainless steel, unless otherwise noted.
 - 3) Liner Material: Polyurethane.
 - 4) Liner Protectors: Covers (or grounding rings) on each end to protect liner during shipment.
 - 5) Electrode Type: Flush or bullet nose as recommended by the manufacturer for the noted stream fluid.
 - 6) Electrode Material: Type 316 stainless steel or Hastelloy C, unless otherwise noted.
 - a) Grounding ring.
 - b) Required, unless otherwise noted.
 - c) Quantity: Two, unless otherwise noted.
 - d) Material: Type 316 stainless steel, unless otherwise noted.
 - 7) Hazardous Area Certification: As noted on Contract Documents.

- b. Analyzer/Transmitter:
 - 1) Mounting: Surface (wall), unless otherwise noted.
 - 2) Display: Required, unless otherwise noted.
 - a) Digital LCD display, indicating flow rate and total.
 - b) Bi-directional Flow Display: Required, unless otherwise noted.
 - (1) Forward and reverse flow rate.
 - (2) Forward, reverse, and net totalization.
 - 3) Enclosure: NEMA 4X, minimum, unless otherwise noted.
 - 4) Analog Output:
 - a) Isolated 4 mA dc to 20 mA dc for load impedance from 0 ohm to at least 500 ohms minimum for 24V dc supply.
 - b) Supports Superimposed Digital HART Protocol: If noted.
- c. Accessories:
 - 1) Cables:
 - a) Types: As recommended by manufacturer.
 - b) Lengths: As required to accommodate device locations.
- 3. Functional Characteristics: Measure, indicate, and transmit the flow of a conductive process liquid in a full pipe.
- 4. Performance Characteristics:
 - a. Element:
 - 1) Electromagnetic flowmeter, with operation based on Faraday's Law, utilizing the pulsed dc type coil excitation principle with high impedance electrodes.
 - 2) Full bore meter with magnetic field traversing entire flow-tube cross-section.
 - 3) Insertion magmeters or multiple single point probes inserted into a spool piece are not acceptable.
 - 4) Stream Fluid: As noted in Instrument Index.
 - 5) Operating Temperature:
 - a) Ambient: Minus 5 degrees F to 140 degrees F, typical, unless otherwise noted.
 - b) Process: Minus 5 degrees F to 140 degrees F, typical, unless otherwise noted.
 - 6) Flow Range: As noted in Instrument Index.
 - 7) Accuracy: Plus or minus 0.5 percent of rate for all flows resulting from pipe velocities of 2 feet to 30 feet per second.
 - 8) Turndown Ratio: Minimum of 10 feet to 1 when flow velocity at minimum flow is at least 1 foot per second.
 - 9) Inlet/Outlet Runs: Certified for 0 x DN Full bore.
 - 10) Features:
 - a) Zero stability feature to eliminate the need to stop flow to check zero alignment.

- b) No obstructions to flow.
 - c) Very low pressure loss.
 - d) Measures bi-directional flow.
- b. Analyzer/Transmitter:
 - 1) Parameter Adjustments: By keypad or non-intrusive means.
 - 2) Empty Pipe Detection:
 - a) If noted.
 - b) Drives display and outputs to zero when empty pipe detected.
 - 3) Built-in Diagnostic System:
 - a) Features:
 - (1) Field programmable electronics.
 - (2) Self-diagnostics with troubleshooting codes.
 - (3) Ability to program electronics with full scale flow, engineering units, meter size, zero flow cutoff, desired signal damping, totalizer unit digit value.
 - (4) Initial flow tube calibration and subsequent calibration checks.

M. F20 Flow Element and Transmitter, Flume/Weir, Radar:

- 1. Manufacturers and Products:
 - a. Endress + Hauser:
 - 1) Sensor: FMR20B.
 - 2) Transmitter: RIA15.
- 2. Physical Characteristics:
 - a. Element:
 - 1) Type: Radar, noncontacting.
 - 2) Approval: CSA C/ US IS Cl.I Div1 Gr.A-D, AEx/ Ex ia IIC T4.
 - 3) Power Supply; Output; Operation: two-wire; 4 mA to 20 mA HART; HART configuration.
 - 4) Antenna Size: 40mm (1-1/2 inch).
 - 5) Maximum Measuring Range: 15 m.
 - 6) Process Connection Rear Side; Material: Thread ASME MNPT1; PVDF; FNPT1 / 2 conduit connection.
 - 7) Process Connection Front Side; Material: Thread ASME MNPT1-1 / 2; PVDF.
 - 8) Cable Length: 20 m per 65 feet.
 - 9) Accessory Enclosed: Mounting bracket adjustable, Type 316L.

- b. Transmitter:
 - 1) Display:
 - a) LCD.
 - b) 3.5-digits.
 - c) 0.35 inch minimum.
 - 2) Enclosure (suitable for field mounting):
 - a) NEMA 4X.
 - b) Wall Mounted.
 - c) Approval: CSA C/ US IS Cl.I Div.1 Gr.A-D, AEx/ Ex ia IIC T4.
 - 3) Power: 24V dc loop-powered.
- c. Signal Interface: 4 mA dc to 20 mA dc at 24V dc maximum.
- 3. Functional Characteristics: Measure indicate, and transmit a flow signal.
- 4. Performance Characteristics:
 - a. Sensor:
 - 1) Range: As noted.
 - 2) Accuracy:
 - a) Sensor: Plus or minus 1 millimeter per meter.
 - b) Flow Calculation: Less than 0.02 percent error.
 - 3) Primary Element:
 - a) Type: As noted.
 - b) Dimensions: As noted.
 - 4) Zero Reference: As noted.
 - b. Transmitter:
 - 1) Accuracy: Plus or minus 0.1 percent of full scale plus or minus one count.
 - 2) Display Update Rate: 2.5 second minimum.
 - 3) Operating Temperature Range: Minus 40 degrees C to 80 degrees C.

N. F51, Flow Element and Transmitter, Thermal Mass:

- 1. Manufacturers and Products:
 - a. Endress + Houser, T-Mass I 300.
 - b. Or equal.
- 2. Physical Characteristics:
 - a. Element:
 - 1) Insertion Length: 9 inches.
 - 2) Wetted Surfaces Materials: Type 316 stainless steel with nickel braze, unless otherwise noted.
 - 3) Seal: PEEK.
 - 4) Process Connection:
 - a) Line Size: As noted or shown.
 - b) Connection Type: 3/4-inch NPT Compression Fitting.
 - c) Connection Material: Type 316 stainless steel, unless otherwise noted.

- b. Transmitter:
 - 1) Display: 4-line by 20-character LCD, keypad programmable.
 - 2) Nonvolatile memory.
 - 3) Signal Interface:
 - a) Outputs: Isolated 4 mA dc to 20 mA dc for maximum 600 ohm load, unless otherwise noted.
 - 4) Power: Selectable: 115V ac, 230V ac, 24V dc.
 - 5) Electrical Connection: 1/2-inch NPT.
 - 6) Enclosure:
 - a) Type: Aluminum NEMA 4X Coated.
 - b) Mounting: Remote from sensor.
 - c. Cables:
 - 1) Length: As required.
 - 2) Cable Jacket: PVC rated for 220 degrees F, unless otherwise noted.
 - 3. Functional Characteristics:
 - a. Function: Directly measure, indicate, and transmit mass flow of process air in pipe.
 - 4. Performance Characteristics:
 - a. Type: Insertion type.
 - b. Process Gas: Air.
 - c. Range: 0 scfm to 3,000 scfm.
 - d. Calibrated Span: As noted.
 - e. Accuracy:
 - 1) Flow: Plus or minus 1 percent of reading plus 0.5 percent full scale.
 - 2) Temperature: Plus or minus 2 degrees F.
 - f. Repeatability:
 - 1) Flow: Plus or minus 0.5 percent of reading.
 - 2) Temperature: Plus or minus 1 degree F.
 - g. Temperature, Operating:
 - 1) Flow Element: Minus 40 degrees F to plus 356 degrees F.
 - h. Pressure, Operating, Flow Element: Up to 290 psig.
- O. L05, Level Element and Transmitter, Ultrasonic:
 - 1. Manufacturers and Products:
 - a. Endress + Hauser:
 - 1) Sensor: Prosonic FDU91.
 - 2) Transmitter: Prosonic S FMU90.
 - b. Or equal.

2. Physical Characteristics:
 - a. Element:
 - 1) NEMA 6P waterproof.
 - 2) Housing: PVDF, unless otherwise noted.
 - a) Other materials subject to Contracting Officer approval.
 - 3) Facing: None, unless otherwise noted.
 - a) Integral Flange: If noted.
 - b) Face: PTFE, unless otherwise noted.
 - c) Size: As noted.
 - 4) Process Connection:
 - a) 1-inch NPT, unless otherwise noted.
 - b) Top mounted.
 - 5) Electrically Hazardous Rating:
 - a) Class I, Division 1, Groups A, B, C, and D: If noted.
 - b) Class II, Division 1, Groups E, F, and G: If noted.
 - c) Other Ratings: As noted.
 - 6) Beam Angle: 12 degrees or less.
 - 7) Integral temperature compensation.
 - b. Transmitter:
 - 1) Display.
 - 2) Integral keypad or nonintrusive external programming.
 - 3) Enclosure: NEMA 4X polycarbonate, unless otherwise noted.
 - 4) Power Supply: 115 volts, 50/60 Hz, unless otherwise noted.
 - 5) Isolated Analog Output:
 - a) One Minimum: 4 mA dc to 20 mA dc for load impedance of 0 ohms to 750 ohms.
 - 6) Digital Communication: As noted.
 - 7) Discrete Outputs:
 - a) Minimum, two relay (SPDT) rated for 2 amps continuous at 230V ac.
 - b) Assignable and as noted.
 - c. Cables: Weatherproof, UV protected, length as required, and type as recommended by manufacturer.
 - d. Accessories:
 - 1) Submergence Shield: If noted.
 - 2) Remote Programming Software: If noted.
 - a) Allows remote programming via computer and echo traces for troubleshooting.
 - b) One per lot of units furnished.
 - 3) Others: As noted.
 - 4) If no integral keypad, furnish one handheld programmer per lot of units furnished.
3. Functional Characteristics: Continuous, non-contacting level measurement.

4. Performance Characteristics:
 - a. Type: Ultrasonic.
 - b. Service:
 - 1) Application: If and as noted.
 - 2) Vapor Space Pressure: Atmospheric, unless otherwise noted.
 - 3) Operating Temperature Range:
 - a) Element: Minus 4 degrees F to plus 149 degrees F.
 - b) Transmitter: Minus 4 degrees F to 113 degrees F.
 - c. Range: As noted.
 - d. Zero Reference: As noted.
 - e. Accuracy: Plus or minus 0.25 percent of maximum range or 6 mm, whichever is greater.
 - f. Resolution: 0.1 percent of range or 2 mm, whichever is greater.
 - g. Blanking Distance: Sensor dependent, typically 1 foot.

P. L18, Level Switch. Float:

1. Manufacturers and Products:
 - a. Contegra; Model FS90.
 - b. Or equal.
2. Physical Characteristics:
 - a. Element:
 - 1) Entire Assembly: Watertight and impact-resistant.
 - 2) Float:
 - a) Material and Size: 5.5-inch diameter polymer-coated, Type 316 stainless steel float.
 - b) Buoyancy: 2 pounds.
 - 3) Mounting:
 - a) Pipe Mounting:
 - (1) Cable clamp, suitable for connection to 1-inch pipe.
 - (2) Pipe-to-wall bracket, suitable for connection to 1-inch pipe.
 - b) Anchor Mounting Kit: If noted.
 - (1) 15-pound vinyl-coated cast-iron anchor.
 - (2) 1/8-inch, Type 316 stainless steel wire rope.
 - (3) Stainless steel cable clips.
 - 4) Signal Interface:
 - a) Switch Type: Magnetic reed.
 - b) Switch Contacts:
 - (1) Isolated, rated at least 0.8 amp continuous at 120V ac.
 - (2) Contact Type: Either NO or NC, as required by application or as noted; or SPDT (NO and NC).

- 5) Cable:
 - a) Length as noted or as necessary per mounting requirements.
 - b) Plastic-jacketed cable, oil-resistant, and suitable for continuous service.
 - c) Accessories: As noted.
3. Functional Characteristics: Actuate contact at preset liquid level.
4. Performance Characteristics:
 - a. Type:
 - 1) Direct-acting, stainless steel float with enclosed, encapsulated switch and integral cable.
 - 2) Mercury free.
 - b. Setpoint: As noted.
 - c. Differential: 8 inches maximum.
 - d. Temperature: 32 degrees F (nonfreezing) to 160 degrees F.

Q. L42 Level Element and Transmitter, Submersible Pressure Transducer:

1. Manufacturers and Products:
 - a. Endress + Hauser:
 - 1) Sensor: Waterpilot FMX21.
 - 2) Transmitter: RIA15.
 - b. Or equal.
2. Physical Characteristics:
 - a. Element:
 - 1) Type: Hydrostatic Level measurement in wastewater.
 - 2) Process Connection: Suspension.
 - 3) Material:
 - a) Level Probe: 316L.
 - b) Process: Ceramic.
 - c) Sensor Sleeve: Polyphenylene Sulfide.
 - d) Seal: PTFE.
 - 4) Temperature compensation.
 - 5) Dimensions, Nominal:
 - a) Diameter: 1.65 inches.
 - b) Length: 9.72 inches.
 - 6) Loop Powered: 9V dc to 30V dc.
 - 7) Signal Interface: 4 mA dc to 20 mA dc output, for load impedance of 0 ohm to 750 ohms, minimum for 24V dc supply without load adjustment.
 - b. Transmitter:
 - 1) Display:
 - a) LCD.
 - b) 3.5-digits.
 - c) 0.35 inch minimum.

- 2) Enclosure (suitable for field mounting):
 - a) NEMA 4X.
 - b) Wall Mounted.
- 3) Power: 24V dc loop-powered.
- 4) Signal Interface: 4 mA to 20 mA dc at 24V dc maximum.
- c. Cable:
 - 1) Length: As required.
 - 2) Polyurethane sheathed, unless otherwise noted.
 - 3) Kevlar strain relief cord.
 - 4) Integral vent tube.
- d. Terminal Bos: IP67 with filter.
- e. Additional Weight: 5 pound weight.
3. Functional Characteristics: Measure and transmit signal proportional to level.
4. Performance Characteristics:
 - a. Sensor:
 - 1) Type: Totally submersible pressure sensor (loop powered).
 - 2) Process Range:
 - a) As noted.
 - 3) Accuracy: 0.25 percent of full scale.
 - 4) Temperature, Operating: Minus 32 degrees F to plus 122 degrees F.
 - 5) Certification(s): Class I, Div 1, Groups A, B, C, and D.
 - b. Transmitter:
 - 1) Accuracy: Plus or minus 0.1 percent of full scale plus or minus one count.
 - 2) Display Update Rate: 2.5 second minimum.
 - 3) Operating Temperature Range: Minus 40 degrees C to 80 degrees C.
 - 4) Certification(s): Class I, Div 1, Groups A, B, C, and D.

R. L128, Level Switch. Float, Dry Well:

1. Manufacturers and Products:
 - a. Gems, LS-270.
 - b. Or equal.
2. Physical Characteristics:
 - a. Material:
 - 1) Stem and Mounting: Type 316 stainless steel.
 - 2) Float: Nitrile rubber.
 - 3) Wetted: Alloy.
 - b. Signal Interface: SPST 20VA, NO.
 - c. Mounting: Bracket.
 - d. Cable: 6ft Neoprene with waterproof connection.

3. Functional Characteristics:
 - a. Actuate contact at preset liquid level.
 - b. Suitable for sensing water on a floor.
4. Performance Characteristics:
 - a. Temperature: Minus 40 degrees F to plus 140 degrees F.
 - b. Suitable for monitoring water and other clear liquids.

S. P03, Differential Pressure Transmitter:

1. Manufacturers and Products:
 - a. Endress + Hauser, PMD75B.
 - b. Or equal.
2. Physical Characteristics:
 - a. Element:
 - 1) Wetted Metallic Parts: Type 316 stainless steel, unless otherwise noted.
 - a) Includes drain/vent valves; process flanges and adapters, and process isolating diaphragm.
 - 2) Bolts and Nuts (if required): Type 316 stainless steel, unless otherwise noted.
 - 3) Fill Fluid: Silicone, unless otherwise noted.
 - 4) Process Connections:
 - a) Line Size: 1/2 inch.
 - b) Connection Type: FNPT.
 - c) Direct/remote Diaphragm Seal: If and as noted.
 - b. Transmitter:
 - 1) LCD indicator, unless otherwise noted.
 - a) Display in either percent or engineering units, field configurable.
 - 2) Signal Interface: 4 mA dc to 20 mA dc output with digital signal based on HART protocol.
 - 3) Enclosure:
 - a) Type: NEMA 4X.
 - b) Materials: Coated aluminum, unless otherwise noted.
 - c. Accessories:
 - 1) Mounting bracket, unless otherwise noted.
 - a) Bracket and Accessories: Stainless steel; suitable for mounting transmitter to panel or 2-inch pipe.
 - 2) Three-valve (isolate and vent) Stainless Steel Manifold: If noted.
3. Functional Characteristics: Measure pressure and transmit signal proportional to pressure.

4. Performance Characteristics:
 - a. Type:
 - 1) Gauge pressure, unless otherwise noted.
 - 2) Electronic variable capacitance or silicon strain gauge.
 - 3) Two-wire transmitter; "smart electronics".
 - b. Range: As noted.
 - 1) Select transmitter's factory upper range limit (URL) such that upper boundary of noted range is as close as possible to 80 percent of factory URL, but does not exceed it.
 - c. Accuracy: Plus or minus 0.075 percent of span, unless otherwise noted.
 - d. Ambient Operating Temperature: Minus 40 degrees F to plus 175 degrees F, with integral meter.
 - e. Process Operating Temperature: Minus 40 degrees F to plus 250 degrees F.
 - f. Humidity: 0 percent to 100 percent relative humidity.
 - g. Hazardous Location Certifications: If and as noted.
 - h. Adjustable damping.

T. P04, Pressure Gauge:

1. Manufacturers and Products:
 - a. Ashcroft; Duragauge Model, 1279 PLUS!.
 - b. Or equal.
2. Physical Characteristics:
 - a. Element:
 - 1) Dial: 4-1/2-inch diameter.
 - 2) Case Material: Black thermoplastic, unless otherwise noted.
 - 3) Materials of Wetted Parts (including element, socket/process connection, throttling device (if specified) and secondary components): Stainless steel, unless otherwise noted.
 - 4) Pointer: Adjustable by removing ring and window.
 - 5) Window: Glass or acrylic, unless otherwise noted.
 - 6) Threaded reinforced polypropylene front ring.
 - 7) Case Type: Solid front with blow-out back.
 - 8) Process Connection:
 - a) Mounting: Lower stem, unless otherwise noted.
 - b) Size: 1/2-inch MNPT, unless otherwise noted.
 - b. Accessories:
 - 1) Throttling Device: Required, unless otherwise noted.
 - a) Type suitable for the intended service.
 - b) Install in gauge socket bore.
3. Functional Characteristics: Local pressure indication.

4. Performance Characteristics:
 - a. Type: Bourdon tube element.
 - b. Scale Range: As noted.
 - c. Accuracy: Plus or minus 0.50 percent of full scale.

U. P06 Pressure Seal, Diaphragm:

1. Manufacturers and Products:
 - a. Ashcroft; Type 201.
 - b. Or equal.
2. Physical Characteristics:
 - a. Materials:
 - 1) Lower Housing: Type 316 stainless steel, unless otherwise noted.
 - 2) Top Housing: Steel, unless otherwise noted.
 - b. Diaphragm: Welded to upper housing, unless otherwise noted.
 - c. Filling screw in upper housing.
 - d. Fill Fluid:
 - 1) Silicone, unless otherwise noted.
 - 2) Factory assembled and filled.
 - e. Flushing Connection: 1/4-inch NPT in lower housing.
 - f. Diaphragm Seal Displacement: 0.1 cubic inch, nominal.
 - g. Connections:
 - 1) Instrument: 1/2-inch female NPT, unless otherwise noted or shown.
 - 2) Process: 1/2-inch female NPT, unless otherwise noted or shown.
3. Functional Characteristics: Isolate sensing element from process fluid.
4. Performance Characteristics:
 - a. Type:
 - 1) Diaphragm.
 - 2) Fluid filled between diaphragm and sensing element.
 - b. Service:
 - 1) Pressure: Same as associated sensor.
 - 2) Temperature Range: If noted.
 - c. Pressure:
 - 1) For threaded process connections, at least 2,500 psig at 100 degrees F.
 - 2) Glycerin Fill: Suitable only for pressure (not vacuum applications).
 - d. Temperature:
 - 1) Dependent upon fill fluid.
 - a) Silicone (food grade): 0 degree F to 375 degrees F.
 - b) Halocarbon: Minus 70 degrees F to 300 degrees F.

5. Diaphragm Material:
 - a. FKM Manufacturers and Products:
 - 1) The Chemours Company, Viton Type A.
 - 2) Or equal.
 - b. Physical Characteristics:
 - 1) Fluoroelastomer (FKM), unless otherwise noted.
 - 2) Maximum Elongation: 150 percent.
 - 3) Specific Gravity: 1.7-1.9.
 - c. Functional Characteristics: None.
 - d. Performance Characteristics:
 - 1) Minimum Hardness: 75 Shore A.
 - 2) Minimum Tensile Strength: 1,450 psi.

V. P07, Pressure Switch:

1. Manufacturers and Products:
 - a. Ashcroft; B Series.
 - b. Or equal.
2. Physical Characteristics:
 - a. Diaphragm Material: Nitrile rubber.
 - b. Adjustable deadband.
 - c. Mounting: Surface, unless otherwise noted.
 - d. Process Connection:
 - 1) 1/4-inch NPT female.
 - 2) Materials: Epoxy coated aluminum.
 - e. Enclosure: NEMA 4X.
 - f. Signal Interface:
 - 1) Contact Type:
 - a) SPDT.
 - b) Rated for 10 amps minimum at 120V ac.
 - 2) Hermetically Sealed Switch: If noted.
3. Functional Characteristics: Monitor pressure, activate switch at setpoint, and deactivate switch at reset point.
4. Performance Characteristics:
 - a. Type:
 - 1) Piston-actuated.
 - 2) Both setpoint and deadband (the differential between setpoint and reset point) adjustable.
 - b. Setpoint:
 - 1) As noted.
 - 2) Repeatability: Plus or minus 1 percent of range.
 - c. Reset Point: As noted.
 - d. Range: The noted setpoint shall fall between 20 percent and 80 percent of the range.
 - e. Deadband: Adjustable within nominally 25 percent and 85 percent of range.

- f. Overpressure Proof Pressure:
 - 1) Pressure psi Ranges: At least 400 percent of rated maximum static pressure.
 - 2) Pressure Inches of Water Ranges: 20 psig.
 - 3) Compound Range: 250 psig.
 - 4) Vacuum Range: 250 psig.
 - 5) Operating Temperature Range:
 - a) Dependent on actuator seal materials.
 - b) For nitrile rubber seal, 0 degree F to 150 degrees F.

W. P09, Pressure Transmitter:

- 1. Manufacturers and Products:
 - a. Endress + Hauser, PMP71B.
 - b. Or equal.
- 2. Physical Characteristics:
 - a. Element:
 - 1) Wetted Metallic Parts: Type 316 stainless steel, unless otherwise noted.
 - a) Includes drain/vent valves; process flanges and adapters, and process isolating diaphragm.
 - 2) Bolts and Nuts (if required): Type 316 stainless steel, unless otherwise noted.
 - 3) Fill Fluid: Silicone, unless otherwise noted.
 - 4) Process Connections:
 - a) Line Size: 1/2 inch.
 - b) Connection Type: FNPT.
 - c) Direct/remote Diaphragm Seal: If and as noted.
 - b. Transmitter:
 - 1) LCD indicator, unless otherwise noted.
 - a) Display in either percent or engineering units, field configurable.
 - 2) Signal Interface: 4 mA dc to 20 mA dc output with digital signal based on HART protocol.
 - 3) Enclosure:
 - a) Type: NEMA 4X.
 - b) Materials: Coated aluminum, unless otherwise noted.
 - c. Accessories:
 - 1) Mounting bracket, unless otherwise noted.
 - a) Bracket and Accessories: Stainless steel; suitable for mounting transmitter to panel or 2-inch pipe.
 - 2) Two-valve (isolate and vent) Stainless Steel Manifold: If noted.
- 3. Functional Characteristics: Measure pressure and transmit signal proportional to pressure.

4. Performance Characteristics:
 - a. Type:
 - 1) Gauge pressure, unless otherwise noted.
 - 2) Electronic variable capacitance or silicon strain gauge.
 - 3) Two-wire transmitter; "smart electronics".
 - b. Range: As noted.
 - 1) Select transmitter's factory upper range limit (URL) such that upper boundary of noted range is as close as possible to 80 percent of factory URL, but does not exceed it.
 - c. Accuracy: Plus or minus 0.075 percent of span, unless otherwise noted.
 - d. Ambient Operating Temperature: Minus 40 degrees F to plus 175 degrees F, with integral meter.
 - e. Process Operating Temperature: Minus 40 degrees F to plus 250 degrees F.
 - f. Humidity: 0 percent to 100 percent relative humidity.
 - g. Hazardous Location Certifications: If and as noted.
 - h. Adjustable damping.

X. P15 Pressure Seal, Annular:

1. Manufacturers and Products:
 - a. Ashcroft; Series 81.
 - b. Or equal.
2. Physical Characteristics:
 - a. Materials:
 - 1) Body: Carbon steel.
 - 2) End Plate: Carbon steel.
 - 3) Flexible Liner: Natural rubber.
 - 4) Fill Fluid: 50/50 Ethylene glycol/water.
 - b. Process Connections:
 - 1) Mounting: In-line.
 - 2) Pipe Size: As noted
 - 3) Connection: ASME B16.5, Class 150-pound flange.
 - c. Factory Filled System: Filled and assembled with pressure monitoring device(s).
3. Functional Characteristics:
 - a. Sense pressure in a process line and transfer to pressure monitoring device.
 - b. Protect attached pressure monitoring device from sludge or slurry.
4. Performance Characteristics:
 - a. Type: Annular fluid-filled device that senses pressure through flexible sleeve around full pipe circumference.
 - b. Operating Conditions: Suitable for line pressures up to pipe flange rating.

Y. T4, Temperature Transmitter:

1. Manufacturers and Products:
 - a. Vaisala; TMW92.
 - b. Or equal.
2. Physical Characteristics:
 - a. Wall mounted, box housing.
 - b. IP Rating: IP30
 - c. Signal Interface: 4 mA to 20 mA loop powered.
3. Functional Characteristics: Measure temperature of HVAC space air.
4. Performance Characteristics:
 - a. Integrated digital sensor.
 - b. Temperature Range: 23 degrees F to 131 degrees F.
 - c. Analog Accuracy: Plus or minus 0.3 degrees F in range minus 68 degrees F to 86 degrees F.

Z. T14 Thermometer, Bimetallic:

1. Manufacture and Products:
 - a. Cole-Palmer; UX-90587-30.
 - b. Or equal.
2. Physical Characteristics:
 - a. Dial:
 - 1) 3-inch circular.
 - 2) Case Material: Type 304 stainless steel.
 - 3) Hermetically sealed.
 - b. Stem:
 - 1) Length: 48 inches
 - 2) Type: 304 stainless steel.
 - 3) Connection: Pointed.
 - c. Functional Characteristics: Measure and indicate temperature.
 - d. Performance Characteristics:
 - 1) Temperature Range: 0 degree F to 200 degrees F.
 - 2) Accuracy: Plus or minus 1 percent.

2.05 PLC PANEL COMPONENTS

A. Panel:

1. Panel Fabrication:
 - a. General:
 - 1) Panels, equipment, and devices shall be braced to prevent damage from specified forces. Equipment panels shall be capable of operation following a disturbance.
 - 2) Nameplates with tag number and equipment description shall identify face-mounted instruments. Instruments shall

- be mounted for access to components and ease of removal. Cutouts for future equipment shall be blanked off with suitable covers. Instrument tag numbers shall be identified on the panel rear.
- 3) Face-mounted equipment shall be flush or semi-flush with flat-black escutcheons. Face-mounted instruments that are more than 6 inches deep, weigh more than 10 pounds, or exert more than a 4-foot-pound moment force on the face of the panel shall be supported underneath at the rear by a 1-inch by 1/8-inch thick steel angle.
 - 4) Panels less than 60 inches high shall be provided with floor stands to raise the top of the panel to 60 inches above the floor or work platform. Panels that weigh less than 100 pounds may be wall-mounted.
 - 5) Panels with specified requirements including stainless steel or aluminum mounting requirements that are indicated on the Drawings or on the Contract Details take precedence over the panel types or panel features indicated herein.
2. Panel Layout:
- a. Provide 20 percent spare contiguous sub-panel area for future expansion.
 - b. Provide minimum of 20 percent spare terminal blocks, with a minimum of 10 analog, discrete, power.
 - c. Provide minimum of 12 inches clear space from the bottom of the panel to the bottom of the subpanel.
 - d. Separation between the power components (over 120V ac) and the control/instrument components (120V ac and less) by locating the power components and the control/instrument components in separate sections of the cabinet enclosure.
 - e. Power cabinet section and the control/instrument cabinet section with separate door handles.
 - f. Separation between the power components and the control/instrument components using barriers.
 - g. External lockable circuit breaker handle for the main panel disconnect.
 - h. Individual power and control components with internal circuit breakers, as required.
 - i. Motor controllers, as required by the equipment specifications.
 - j. Displays with door-in-door construction accessible by opening the cabinet outer door.
 - k. Face-mounted equipment flush or semi-flush with flat-black escutcheons.
 - l. Panel Tops of Wall-mounted Panels: Mounted at the same elevation.
 - m. Panel inner door contains a copy of the record elementary and wiring diagrams, or reference as allowed per NEC Article 409.

- n. Panel inner door contains a drawing holder.
 - o. Panel drawings enclosed in a transparent, protective jacket.
 - p. Panel functions as specified.
 - q. Panels with floor stands, to raise the top of the panel to 60 inches above the floor or work platform.
 - r. Wall-mounting of panel weighs less than 100 pounds, where wall space is available.
3. Enclosures:
- a. Panel enclosures shall comply with the requirements of NEC Article 409 and NEMA 250.
 - b. Enclosure rating and material requirements shall be in accordance with the Area Classification Table and Material Selection Table on the Drawings.
4. Heating, Ventilating, and Cooling:
- a. Forced air ventilation shall be provided for panels if the cabinet's heat load calculations indicate that the interior temperature of the cabinet will exceed the rating of the device with the lowest temperature for that device within the enclosure, under worst case conditions.
 - b. Ventilation for panel racks shall be venturi fans provided on 5-1/2-inch high-notched panel. Ventilation for consoles shall be similar to that for panel racks except EIA RS-310 mounting is not required. Fans shall be equipped with UL-approved washable filters and provide at least 240 cubic feet per minute (cfm). Fans shall be thermostatically controlled. Noise level at 3 feet from exterior wall and 30 degrees off axis shall not exceed 60 NC units.
5. Nameplates:
- a. External door-mounted components and the panel description shall be identified with phenolic nameplates. Machine embossed metallic adhesive labels shall identify tag number of instruments inside panels. Nameplates shall be attached to panel surfaces, not to instruments.
 - b. The machine engraved laminated black phenolic nameplates with white lettering shall be provided for panel-mounted equipment. Nameplate engraving shall include the instrument tag number and description in 3/32-inch minimum size lettering.
 - c. The machine embossed metallic adhesive labels shall identify tag number of instruments inside panels. Nameplates shall be attached to panel surfaces, not to instruments.
 - d. The nameplates shall be attached to the panel with a minimum of two self-tapping Type 316 stainless steel screws. Provide RTV sealant for nameplates for NEMA 4X stainless steel panels.
 - e. The nameplate wording may be changed without additional cost or time prior to commencement of engraving. Submit nameplate legend with the panel submittal, as described in Section 40 90 00, Instrumentation and Control for Process Systems.

6. Panel Features:
 - a. Interconnection Wiring:
 - 1) Panel Interconnecting Wiring:
 - a) Panel Control Wiring: Single conductor stranded copper NEC rated Type MTW 16 AWG minimum (rated 10 A per NFPA 79, Table 12.5.1), with an exception for factory-supplied PLC wiring harnesses that are U.L. approved.
 - b) Panel Instrument Wiring: Twisted 16 AWG shielded pair or tri conductors.
 - c) Panel Power Wiring: Conductors specified in Division 26, Electrical and meet the NEC requirements for power including phase, grounded, and grounding conductors.
 - d) Wiring shall be supported independently of terminations by lacing to panel support structure or by slotted flame-retardant plastic wiring channels.
 - e) Wiring channels shall comply with UL 94, Type V.
 - f) Plastic wireway with covers shall be used to route groups of wires. Wireway fill shall be sized to provide 50 percent maximum fill.
 - g) Plastic spiral wrap shall be used for exposed wires. Wires that cross door hinges shall be enclosed in plastic spiral wrap.
 - h) Wiring color conventions and standards shall comply with the requirements in Division 26, Electrical.
7. Conductor Identification:
 - a. Conductor identification shall comply with the requirements specified in Division 26, Electrical.
 - b. Wiring shall be tagged at terminations with machine-printed plastic sleeves with three-part wire numbers for instrument and control panel internal conductors:
 - 1) Part-1: Prefix of the wire number shall be the instrument loop number or equipment tag number.
 - 2) Part-2: Code letter and wire colors per the following tables.
 - 3) Part-3: Number that identifies individual circuit conductor Terminal Number.

Code	120V ac Conductor	Color
L	Power	Black
C	Control	Red
N	Neutral	White
PG	Ground	Green

Code	V dc Conductor	Color
PS	24V dc Power	Blue
PS	12V dc Power	Violet
S+	Signal (+)	Black
SG	Signal Ground	White
EG	Equipment Ground	Green
FV	Panel Foreign Voltage	Yellow

c. Conductor Identification:

- 1) Wiring shall be tagged at terminations with machine-printed plastic sleeves with three-part wire numbers for instrument and control panel internal conductors:
 - a) Part-1: Prefix of the wire number shall be the instrument loop number or equipment tag number.
 - b) Part-2: Code letter and wire colors per panel standard.
 - c) Part-3: Number that identifies individual circuit conductor Terminal Number.

8. Conductor Installation and Protection:

- a. Power and control wiring shall be carried in covered channels separate from low voltage signal circuits. An interior steel barrier shall be provided between AC control devices and the electronic equipment.
- b. Terminal blocks shall be strap screw type rated for 600 volts. Each terminal trip shall have a unique identifying alphanumeric code at one end and a vinyl-marking strip running the entire length of the terminal strip with a unique number for each terminal. Numbers shall be machine printed and 1/8-inch high.
- c. No more than two connections shall be made to one terminal.
- d. Wire connectors shall be locking fork tongue or ring tongue insulated crimp type terminals.

9. Field Wiring: Field wiring shall be connected to separate dedicated terminal blocks in a dedicated part of the panel where the field cables enter the panel. Provide a dedicated raceway on the field side of the terminal block for field wiring use only.

10. Fuse and Fuse Holders:

- a. Fuses for 120V ac circuits shall have a minimum of 12,000 amperes interrupting capacity and blown fuse indicators.
- b. Fuses for 24V dc circuits shall be fast-acting glass tube type rated 1/8 amp or 1/10 amp for 4 mA to 20 mA loops.
- c. Fuses for 24V dc circuits shall be 1/2 amp for the power supply to individual instruments.
- d. Fuse holders shall be tip-out or draw-out type.

11. Control Power:
 - a. One 120V ac, UPS supplied circuit, for control power source: Dual, redundant with diode auctioneered outputs and automatic-switching between power sources, one for PLC and DC power and one for PLC output and input control power.
 - 1) Provide control power transformers, as required for the load.
 - 2) Provide direct current power supplies, as required for the load.
 - 3) UPS power source for PLC and derived loop power as defined above, supplied to each control panel.
12. Panel Utility Power Source: One 120V ac circuit, non-UPS, for all auxiliary systems within the panel including the panel light, receptacle, heating, fan, and other similar items as required.
 - a. Non-UPS circuit supplied to each control panel.
13. Accessories:
 - a. Panels greater than 24 inches high by 24 inches wide shall include GFCI convenience receptacles and fluorescent utility lights.
 - b. Receptacles and utility lights shall not be powered by the UPS, where included.
 - c. Print pocket.
 - d. Fold-up shelf of sufficient size, sufficient weight capacity, and the proper angle for supporting a laptop computer.
14. Fail-Safe Wiring: Fail-safe wiring of control relay or other on/off device or instrument provides the condition that will occur upon loss-of-power or internal failure in the device such that the relay is de-energized in the failure or loss-of-power condition such that the control relay contact operation provides for equipment failing in a safe mode.
15. Control Devices: Control devices shall comply with Division 26, Electrical.
16. Indicating Lights: Indicating lights shall be equipped with colored lenses as specified in Division 26, Electrical.
17. Power Supply and Conditioning Equipment:
 - a. Except for power supply units which form an integral part of an individual piece of equipment, all power supply and conditioning equipment shall comply with UL 1012 and shall be approved by UL, CSA, or FM for the application. All power supply equipment shall be provided in redundant configurations such that failure of a single unit will not disable all or any part of the instrumentation and communication systems. Diode isolation shall be provided for redundant direct current supply units, and the power supply negative output terminal shall be grounded.
 - b. Alternating Current (AC) Voltage Regulators: Regulators shall be of the solid-state tap-changing type, insensitive to line frequency variations between 47 Hz and 63 Hz. Ferroresonant units are not acceptable. Output regulation for input voltage variation from 85 volts to 125 volts shall not exceed 3.3 percent. Output

regulation for load variation from 0 percent to 100 percent shall not exceed 1.0 percent. Response time shall be 1.0 cycles or less. Voltage regulators serving panelboards and control panels shall have a load capacity not less than 200 percent of the connected load. Voltage regulators serving individual instruments shall have a load capacity not less than 125 percent of the connected load. Power loss in the regulator shall not exceed 2 percent of the regulator capacity, and harmonic distortion introduced by the regulator shall not exceed 0.1 percent. Regulator output shall be fully protected against internal faults, external overloads and short circuits. Three-phase units shall be four-wire, wye-connected, and capable of supporting 100 percent unbalanced load.

- c. Noise-Suppression Isolation Transformers: Isolation transformers shall be provided for AC-powered instrumentation loads containing solid state circuitry where such is not included within the instrument. Isolation transformers shall be of the triple box shield type. Each coil shall be completely enclosed in a grounded conductive faraday shield, and the overall transformer enclosed in a faraday shield. Common mode noise attenuation between primary and secondary shall exceed 140 dB at 1.0 kHz. Isolation transformer dielectric strength shall be 2,500 volts minimum. Isolation transformers serving panelboards and control panels shall have a load capacity not less than 200 percent of the connected load. Isolation transformers serving individual instruments shall have a load capacity not less than 125 percent of the connected load. Power loss in the isolation transformer shall not exceed 2.0 percent of the maximum load rating. Harmonic distortion introduced by the isolation transformer shall not exceed 0.1 percent. Three-phase units shall be four-wire, wye-connected and capable of supporting 100 percent unbalanced load.

- d. Direct-Current Power Supplies:

- 1) Except for power supply units which form an integral part of an individual piece of equipment, all power supply and conditioning equipment shall comply with UL 1012 and shall be approved by UL, CSA, or FM for the application. All power supply equipment shall be provided in redundant configurations such that failure of a single unit will not disable all or any part of the instrumentation and communication systems. Provide DIN rail mount dual power supplies with DIN rail mount automatic switching power supply redundancy manager between power supplies. The power supply negative output terminal shall be grounded.
- 2) Furnish as required to power instruments and control circuits requiring dc power, including two-wire transmitters,

- relays, PROFIBUS panels, PROFIBUS instruments, PROFIBUS networks, and internal panel control devices.
- a) Supplier shall provide sizing calculations for each power supply in submittals, as described in Section 40 90 00, Instrumentation and Control for Process Systems.
 - 3) Convert 120V ac, 60 Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
 - 4) Provide output over voltage and over current protective devices to:
 - a) Protect instruments from damage due to power supply failure.
 - b) Protect power supply from damage due to external failure.
 - 5) Enclosures: NEMA 1.
 - 6) Mount such that dissipated heat does not adversely affect other components.
 - 7) Fuses: For each dc supply line to each individual two-wire transmitter.
 - 8) Type: Indicating.
 - 9) Mount so fuses can be easily seen and replaced
 - 10) Nominal 24V dc instrumentation and control power supply:
 - a) Convection-cooled linear type or switching type.
 - b) Line Regulation: 0.4 percent for line variations from 105 volts to 132 volts.
 - c) Load Regulation: 0.4 percent for load variations from 0 to full load.
 - d) Ripple and Noise: Not exceed 100 mV peak-to-peak.
 - e) Hold-up Time at Maximum Load: Not less than 16 milliseconds.
 - f) Continuous duty from 0 degree C to 50 degrees C at rated load.
 - g) Output electronically current limited.
 - h) Over-voltage crowbar shutdown.
 - 11) Adjustable plus or minus 5 percent.
 - 12) Set to provide 26.4 volts to the panel direct current bus.
 - a) Provide dry contact for failure alarm. Dry contact to be wired as input to PCS.
18. Surge Protection:
- a. Provide primary surge protectors, per NEC Article 800.90 on all signal conductors entering the panel. Surge protectors shall be multi-stage, plug-in type selected to protect the equipment, and listed per ANSI/UL 497. Surge protectors shall be removable without changing the impedance of the circuit.

- b. Provide Type 1 surge protective devices, per NEC Article 285, at the power feed to the panel. Surge Protective Devices (SPD) shall be designed to provide transient voltage protection for a service entrance panelboard. SPD units shall comply with UL 1449 3rd Edition, and shall be listed for such use. SPD units shall be rated for the voltage and phase service of the panel at 120 kA per phase. SPD units shall have a built-in diagnostic package with flashing trouble indicator, a display for the status of each phase, and a counter and display to indicate the number of surges that have caused the device to operate.
 - c. Surge arrestors and capacitors shall be provided on the primary winding of isolation transformers supplying power to solid state systems. Surge protectors shall be mounted in a separate, NEMA 1 enclosure adjacent to the transformer and the incoming line passed through this enclosure.
19. Panel Grounding:
- a. Each panel shall be provided with two copper ground bars.
 - 1) One bar (NEC required) shall be bonded to the panel or panel frame or back-plate and to the facility grounding system.
 - 2) Second (signal) ground bar shall be mounted on insulated stand-offs and shall be bonded to the panel ground bar only at one point.
 - b. Signal circuits, signal cable shields, and low-voltage DC power supply commons shall be bonded to the signal ground bar.
 - c. Field analog wiring shields shall only be grounded at the signal ground bar. Test to verify that single ground point at panel signal ground bar.
 - d. Surge protectors and separately derived AC power supplies shall be bonded to the frame ground bar.
 - e. Panels exceeding 36 inches width shall contain ground bars shall be 1/4-inch by 1-inch copper bars extending the entire length of the panel interior at the bottom of the panel.
20. Interlocks: Critical interlocks shall not rely on soft interlocks derived from analog instruments or software logic but must be discrete switches that are hardwired to the motor control circuit directly. These interlocks shall be identified and submitted to the Contracting Officer on motor elementary drawings.
21. Panel Drawing Protection: Provide a complete set of panel-wiring diagrams and schematics for each panel in a plastic bag or plastic container to avoid water damage and aging.

B. Programmable Logic Controllers:

1. Processor

a. Manufacturers and Products:

- 1) Do-more H2-DM1E.
- 2) No or equal.

b. Physical Characteristics:

- 1) Mounting: Rack.

c. Functional Characteristics:

- 1) The PLC processors shall be sized with sufficient memory to process the package control system application control strategies, including all hardwired I/O, all PCSI monitoring and control I/O, while also providing memory for a 100 percent expansion of processing and memory capacity. Provide latest version at time of Offer with processor memory sized for twice the tested and completed PLC program.
- 2) All PLC control logic configuration programs shall provide the functionality, content, format and documentation specified in equipment specifications.
- 3) Provide latest version at time of Offer with processor memory sized for twice the tested and completed PLC program.
- 4) Total Memory: 262 KB.
- 5) Ladder Memory: 65k instruction words.
- 6) Built-in Communications Ports: Ethernet (10/100 Base-T).
- 7) Local I/O Points Available: 256.
- 8) Remote I/O Discrete Points Available: 131k.
- 9) Remote I/O Analog Points Available: 32k.
- 10) No. of Ethernet Slave Per Channel: 16.
- 11) Programming Language: Ladder Logic.

d. Performance Characteristics:

- 1) Operating Temperature: 32 degrees F to 131 degrees F.
- 2) Ambient Humidity: 30 percent to 90 percent.
- 3) Approvals: UL508.

2. Rack:

a. Manufacturers and Products:

- 1) D-more.
 - a) 4 Slot Rack: D2-04B-1.
 - b) 6 Slot Rack: D2-06B-1.
 - c) 9 Slot Rack: D2-09B-1.

b. Physical Characteristics:

- 1) Input Voltage: 120V ac.
- 2) Power Requirements: 80VA.

c. Functional Characteristics: None.

- d. Performance Characteristics:
 - 1) Operating Temperature: 32 degrees F to 131 degrees F.
 - 2) Ambient Humidity: 30 percent to 90 percent.
- 3. Remote I/O Master Ethernet Module:
 - a. Manufacturers and Products:
 - 1) Do-more H2-ERM100.
 - 2) No or equal.
 - b. Physical Characteristics:
 - 1) Mounting: Rack.
 - c. Functional Characteristics:
 - 1) Provide quantity as shown on the block diagrams on the Drawings, or as required by the package system specifications.
 - 2) Communications: 10/BaseT Ethernet.
 - 3) Ethernet Protocols:
 - a) TCP/IP.
 - b) Modbus TCP/IP.
 - c) Ethernet/IP.
 - 4) No of Connections: 16.
 - d. Performance Characteristics:
 - 1) Operating Temperature: 32 degrees F to 131 degrees F.
 - 2) Ambient Humidity: 30 percent to 90 percent.
- 4. Remote I/O Slave Ethernet Module:
 - a. Manufacturers and Products:
 - 1) Do-more H2-EBC100.
 - 2) No or equal.
 - b. Physical Characteristics:
 - 1) Mounting: Rack.
 - c. Functional Characteristics:
 - 1) Provide quantity as shown on the block diagrams on the Drawings, or as required by the package system specifications.
 - 2) Communications: 10/BaseT Ethernet.
 - 3) Ethernet Protocols:
 - a) TCP/IP.
 - b) Modbus TCP/IP.
 - c) Ethernet/IP.
 - d. Performance Characteristics:
 - 1) Operating Temperature: 32 degrees F to 131 degrees F.
 - 2) Ambient Humidity: 30 percent to 90 percent.
- 5. Analog Input Modules:
 - a. Manufacturers and Products:
 - 1) Do-more F2-08AD-1.
 - 2) No or equal.
 - b. Physical Characteristics:
 - 1) Mounting: Rack.

- c. Functional Characteristics:
 - 1) No. of Channels: 8.
 - 2) Input Range: 4 mA to 20 mA.
 - 3) Input Type: Non-Isolated.
 - 4) Resolution: 4096.
 - 5) Source Power: 24V dc external.
 - d. Performance Characteristics:
 - 1) Operating Temperature: 32 degrees to 131 degrees F.
 - 2) Ambient Humidity: 30 percent to 90 percent.
 - 6. Analog Output Modules:
 - a. Manufacturers and Products:
 - 1) Do-more F2-02DAS-1.
 - 2) No or equal.
 - b. Physical Characteristics:
 - 1) Mounting: Rack.
 - c. Functional Characteristics:
 - 1) No. of Channels: 2.
 - 2) Output Range: 4 mA to 20 mA.
 - 3) Output Type: Isolated.
 - 4) Resolution: 65536.
 - 5) Source Power: 24V dc external.
 - d. Performance Characteristics:
 - 1) Operating Temperature: 32 degrees F to 131 degrees F.
 - 2) Ambient Humidity: 30 percent to 90 percent.
 - 7. Digital Input Modules:
 - a. Manufacturers and Products:
 - 1) Do-more D2-16ND3-2.
 - 2) No or equal.
 - b. Physical Characteristics:
 - 1) Mounting: Rack.
 - c. Functional Characteristics:
 - 1) No. of Inputs: 16.
 - 2) Input Voltage: 24V dc.
 - 3) Input Type:
 - a) Inputs 1 – 8 Common Source.
 - b) Inputer 9 – 16 Common Source.
 - 4) Source Power: 24V dc external.
 - d. Performance Characteristics:
 - 1) Operating Temperature: 32 degrees F to 131 degrees F.
 - 2) Ambient Humidity: 30 percent to 90 percent.
 - 8. Digital Output Modules:
 - a. Manufacturers and Products:
 - 1) Do-more D2-08TR.
 - 2) No or equal.
 - b. Physical Characteristics:
 - 1) Mounting: Rack.

- c. Functional Characteristics:
 - 1) No. of Outputs: 8.
 - 2) Output Type:
 - a) Relay, Form A SPST.
 - b) Common Source.
 - 3) Source Power: External 24V dc or 120V ac.
 - 4) Interposing Relays: Required.
- d. Performance Characteristics:
 - 1) Operating Temperature: 32 degrees F to 131 degrees F.
 - 2) Ambient Humidity: 30 percent to 90 percent.

C. Graphic Display Terminal:

- 1. Manufacturers and Products:
 - a. Industrial Monitor:
 - 1) Hope Industrial Systems; Model HIS-ML23.8-FPVA.
 - 2) Or equal.
 - b. Thin Client Computer:
 - 1) Dell; Model Optiplex Micro FF.
 - 2) Or equal.
 - c. Keyboard:
 - 1) Hope Industrial Systems; Model KB-R2-WMT-BLK-4-USB.
 - 2) Or equal.
- 2. Physical Characteristics:
 - a. Industrial Monitor:
 - 1) Type: Panel Mounted Multi-Touch PCAP Touch Screen.
 - 2) Display: 23.8 inches (1920 by 1080).
 - 3) Material: Edge to edge bezel.
 - 4) Video: DVI-I, display port.
 - 5) Environmental: NEMA 4X.
 - 6) Input Power: 120V ac or 24V dc.
 - b. Thin Client Computer:
 - 1) Processor: Intel Core i3.
 - 2) Processor Speed: 4.4 GHz Turbo.
 - 3) Cache: 12 MB.
 - 4) Number of Cores: 4.
 - 5) Operation System: Windows 11 Pro.
 - 6) Memory: 8 GB DDR5.
 - 7) Storage: 256 GB SSD.
 - 8) Network Communications: 100Base-T.
 - 9) Mounting: Desktop.
 - c. Keyboard:
 - 1) Type: Folding wall mount with button pointer.
 - 2) Material: Black powder-coated carbon steel.

- 3) Connection: USB.
- 4) Environment: NEMA 4.
3. Functional Characteristics: None.
4. Performance Characteristics: None.

D. Network Switches:

1. Manufacturers and Products:
 - a. Managed Switch (Business and SCADA):
 - 1) Cisco; Catalyst 3100 Series.
 - 2) Or equal.
 - b. Unmanaged Switch (I/O):
 - 1) Moxa; Model EDS-316.
 - 2) Or equal.
2. Physical Characteristics:
 - a. Managed Switch:
 - 1) Form Factor: Din rail mount.
 - 2) Network Connections:
 - a) 18 x 10/100/1000BASE-TX: RJ-45 ports.
 - b) 2 X 1 Gbe combo ports.
 - 3) Operating Temperature: Minus 40 degrees C to plus 60 degrees C.
 - 4) Input Power: 9V dc to 60V dc.
 - 5) Protection Class: IP30.
 - b. Unmanaged Switch:
 - 1) Form Factor: Din rail mount.
 - 2) Network Connections: 16 x 10/100BASE-TX: RJ-45 ports.
 - 3) Operating Temperature: Minus 40 degrees C to plus 60 degrees C.
 - 4) Input Power: 9V dc to 60V dc.
 - 5) Protection Class: IP30.
3. Functional Characteristics: None.
4. Performance Characteristics:
 - a. Managed Switch:
 - 1) Layer 2 switching.
 - 2) Multicast (IGMP Snooping/Querier).
 - 3) Management: Web interface, SNMP v3.
 - 4) Security: DHCPv6 Guard.
 - 5) IEEE 802.1
 - 6) Layer 3 Routing: Inter-VLAN, static routing.
 - 7) Industrial Ethernet: SCADA protocol classification.
 - 8) Redundancy: Resilient Ethernet Protocol (REP), Media Redundancy Protocol (MRP).
 - 9) Industrial Management: Layer 3 network address translation.
 - 10) Approvals: UL 60950-1.

- b. Unmanaged Switch:
 - 1) IEEE 802.3
 - 2) Approvals: UL 60950-1.

E. Fiber-Patch Panel:

- 1. Manufacturers and Products:
 - a. Dinspace; SNAPXL-24LC-SM.
 - b. Or equal.
- 2. Physical Characteristics:
 - a. Material: 18 gauge powder coated steel.
 - b. Mounting: Din-Rail.
 - c. Connectors:
 - 1) Fiber Type: Single-Mode.
 - 2) Connector Type: LC Duplex.
- 3. Functional Characteristics: None.
- 4. Performance Characteristics: None.

F. Power Supply:

- 1. Manufacturers and Products:
 - a. Solo/Hevi-Duty SDN-20-24-100P.
 - b. Or equal.
- 2. Physical Characteristics:
 - a. Input: 120VAC, 2.2A.
 - b. Output: 24 VDC, 10A.
 - c. Mounting: Din-rail.
 - d. Enclosure: NEMA 1.
- 3. Functional Characteristics: None.
- 4. Performance Characteristics: None.

2.06 SCADA SERVER COMPONENTS

A. SCADA Software: SCADA software will be provided and programmed by NPS's SI.

B. Server Hardware:

- 1. Manufacturers and Products:
 - a. Nutanix; Model NX-1365-G9.
 - b. Or equal.
- 2. Physical Characteristics:
 - a. Form Factor: 19-inch rack mount 2U.
 - b. Processor: Dual Intel Xeon 5th Generation.
 - c. Max Memory: 1,064 GB.
 - d. Max Processor Cores: (24 Cores per CPU socket).
 - e. Number of CPU Sockets: Three.

- f. Maximum Storage Capacity: 43.86 TB.
- g. Storage Type: SSD_HDD, SSD+HDD SED
- h. Network Connections: 25 Gbe, 10 Gbe, and 10GBASE-T.
- i. Operating System: None. NPS to provide.
- j. Power Input: Dual redundant failover 120V ac.
- 3. Functional Characteristics: None.
- 4. Performance Characteristics: None.

C. SCADA Server Storage Subsystem:

- 1. Manufacturers and Products:
 - a. Network Attach Storage:
 - 1) Synology; Model RS822RP+.
 - 2) Or equal.
 - b. Internal Hard Drive:
 - 1) Seagate; Model ST10000VN008.
 - 2) Or equal.
 - c. External Hard Drive:
 - 1) Western Digital; Model WDBWLG0100HBK-NESN.
 - 2) Or equal.
- 2. Physical Characteristics:
 - a. Network Attached Storage:
 - 1) Processor: AMD Ryzen V1500B quad-core (8-thread) 2.2 GHz.
 - 2) Memory: 2 GB DDR4 ECC SODIMM (expandable up to 32 GB).
 - 3) Network Connections:
 - a) Native 4 x 1 Gbe.
 - b) Optional 10/25 Gbe.
 - 4) Form Factor: 19-inch rack mount, 1U.
 - 5) Compatible Drive Types: 4 x 3.5-inch SATA HDD/SCC.
 - 6) Operating System: Synology DiskStation Manager (DSM).
 - b. Internal Hard Drive:
 - 1) Capacity: 10 TB.
 - 2) Type: 3.5-inch SATA HDD.
 - 3) Interface: SATA 6 Gb/s.
 - c. External Hard Drive:
 - 1) Capacity: 12 TB.
 - 2) Type: Portable HDD.
 - 3) Interface: USB 3.0.
- 3. Functional Characteristics: None.
- 4. Performance Characteristics: None.

D. SCADA Management Workstations:

1. Manufacturers and Products:
 - a. Dell; Model 7960.
 - b. Or equal.
2. Physical Characteristics:
 - a. Form Factor: 19-inch rack mount 2U.
 - b. Processor: Intel Xeon Silver.
 - c. Processing Speed: 3.9 GHz.
 - d. Cache: 30 MB.
 - e. No. of Cores: 12.
 - f. Operating System: None. Provided by NPS.
 - g. Storage: 2 TB, with options for 7 more.
 - h. Network Communications: 2 x 1 Gbe.
3. Functional Characteristics: None.
4. Performance Characteristics: None.

E. Network Switches:

1. Manufacturers and Products (Business and SCADA):
 - a. Cisco; Catalyst 9300 Series.
 - b. Or equal.
2. Physical Characteristics:
 - a. Form Factor: 19-inch rack mount 1U.
 - b. Network Connections:
 - 1) Non-POE Switch:
 - a) 24 x 1 Gbe.
 - b) 4 x SM 1G SFP.
 - 2) POE Switch:
 - a) 24 x POE.
 - b) 4 x SM 1G SFP.
 - c. Input Power: 100V ac to 240V ac.
3. Functional Characteristics: None.
4. Performance Characteristics:
 - a. Layer 2 switching.
 - b. Multicast (IGMP Snooping/Querier).
 - c. Management: Web interface, SNMP v3.
 - d. Security: DHCPv6 Guard.
 - e. IEEE 802.1.
 - f. Layer 3 Routing: Static Routing, OSPFv3, RIP, PBR.
 - g. Industrial Ethernet: SCADA Protocol Classification.
 - h. Redundancy: Resilient Ethernet Protocol (REP), Media Redundancy Protocol (MRP).
 - i. Industrial Management: Layer 2 switching.
 - j. Approvals: UL 60950-1.

F. Server and Panel Enclosures:

1. Server and Network Racks: Racks shall be of the standard 19-inch by 7-foot style typical of the industry. Vertical members shall be drilled and tapped to accept #10-24 screws on industry-standard spacing and pattern. Fully perforated front and rear doors and fully perforated top to allow maximum air movement around equipment. Conforms to server manufacturer's open space requirements.
2. Patch Panels: Patch panels shall be constructed of 0.118-inch aluminum plate with black anodized coating and white screen printed markings. The panels shall be manufactured to fit the standard 19-inch rack width with mounting holes matching the threaded holes in the rack vertical members. The panel shall be configured as six-port replaceable modules containing standard modular jacks. The front of each module shall be capable of accepting 9-mm to 12-mm labels. Each port shall be capable of accepting an icon label to indicate its function.
3. Fiber Optic Enclosures: Fiber optic enclosures shall provide support frames for single mode LC inserts unless otherwise specified or specified on the Drawings. Enclosures shall fully enclose both the hardwired and the patch-cord connections.

G. Large TV Scada Monitor:

1. Manufacturers and Products:
 - a. Vizio; V4K65M-0804.
 - b. Or equal.
2. Physical Characteristics:
 - a. Size: 65 inches.
 - b. Resolution: 4K (2160P).
 - c. Display Technology: LED.
 - d. Dynamic Range Format: HDR10+.
 - e. Inputs: 3 x HDMI.
 - f. Wireless Technology: Wifi6.
 - g. Mounting: Wall.
3. Functional Characteristics: None.
4. Performance Characteristics: None.

H. SCADA Workstation:

1. Manufacturers and Products:
 - a. Thin Client Computer:
 - 1) Dell; Model Optiplex Micro FF.
 - 2) Or equal.

2. Physical Characteristics:
 - a. Thin Client Computer:
 - 1) Processor: Intel Core i3.
 - 2) Processor Speed: 4.4 GHz Turbo.
 - 3) Cache: 12 MB.
 - 4) Number of Cores: 4.
 - 5) Operation System: Windows 11 Pro.
 - 6) Memory: 8 GB DDR5.
 - 7) Storage: 256 GB SSD.
 - 8) Network Communications: 100Base-T.
 - 9) Mounting: Desktop.
 - 10) Keyboard: US English.
 - 11) Mouse: Optical.
 - 12) Monitor: 24 inches (1080P).
3. Functional Characteristics: None.
4. Performance Characteristics: None.

PART 3 EXECUTION (NOT USED)

END OF SECTION