#### SECTION 15090

## VALVE ACTUATORS

#### PART 1 - GENERAL

### 1.01 SECTION INCLUDES

A. Manual and powered actuators for proper operation of all valves required for equipment or systems.

# 1.92 RELATED SECTIONS

- A. Section 09900—Painting and Coating.
- B. Section 15060—Pipe and Pipe Fittings.
- C. Section 15100-Valves, Cocks and Hydrants.
- D. Section 15103-Butterfly Valves.
- E. Section 16010----General Electrical Requirements.

### 1.03 REFERENCES

- A. ANSI B93.114---Pneumatic Fluid Power-Systems Standard for Industrial Machinery.
- B. AWWA C500---Metal Scated Gate Valves for Water Supply Service.
- C. AWWA C540-Power-Actuating Devices for Valves and Sluice Gates.
- D. NEMA ICS-2---Industrial Control and Systems Controllers, Contactors, and Overload Relays Not More Than 2000 Volts AC or 750 Volts DC.

#### 1.04 SUBMITTALS

- A. Submit under provision of Section 01330.
- B. Product data: Provide complete data on valve accessories sufficient to verify compliance with the Specifications:
  - 1. Provide manufacturer's catalog information with size, dimensions, number of turns to open, materials and assembled weights.
  - 2. Provide wiring and control diagrams for valves with electric actuators.

### 1.05 OPERATION AND MAINTENANCE MANUAL

- A. Submit under provisions of Section 01805.
- B. Maintenance data: Include installation and maintenance instructions, recommended spare parts lists and exploded assembly views of actuators and accessories.

#### 1.96 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 01600.
- B. Prepare valves accessories for shipment according to AWWA C540, Section 7.2.

#### PART 2 - PRODUCTS

## 2.01 MANUAL ACTUATORS

- A. General:
  - 1. Provide a manual actuator except where valves are to have motor or cylinder actuator.

- 2. Buried valves or valves operated through floor boxes and as indicated on drawings: Wrench nuts.
- 3. Adequate to seat, unseat, and maintain valve position under all operating conditions.
- 4. Provide with position indicator on each actuator or each operating nut.
- 5. Position valve actuators so that they are easily accessible, and for ease of operation
- B. Rotation:
  - 1. Counter clockwise (to the left) to open.
  - 2. The word "OPEN" and an arrow indicating the direction to open cast on each valve body or actuator.
- C. Handwheel actuator:
  - 1. Totally enclosed worm gear actuator.
  - 2. Handwheel diameter: 6-24 inches.
  - 3. Max pull required: 80 lb.
  - 4. Withstand 200 lb pull without damage.
- D. Chain wheel actuator:
  - 1. Totally enclosed worm gear actuator, permanently lubricated and with sealed bearings.
  - 2. Equipped with chain guide to permit rapid chain handling of the chain without "gagging" the wheel and to permit reasonable side pull on the chain.
  - 3. With extensions as required to prevent interference with adjacent piping or equipment.
  - 4. Chain:
    - a. Hot-dip galvanized carbon steel except where specified otherwise.
    - b. Looped to extend within 3 feet to 4 feet of the floor or finish grade below valve.
    - c. Smooth, welded, closed link type.
    - d. Overlapping, open link type is not acceptable.
  - 5. Max pull required: 80 lb.
  - 6. Withstand 200 lb pull without damage.
  - 7. For valves placed in a horizontal run, provide 90 degree or 270 degree gearing for actuator.
  - Install chain wheel actuators of valves that are higher than 6' above floor or other working platforms
- E. Wrench nuts:
  - 1. AWWA C500, Section 19.
  - 2. Withstand 300 foot lb torque without damage.
  - 3. Readily locked in the open, closed, and not less than five intermediate positions.
- F. Extension stems:

- 1. Provide where indicated on Drawings, or as specified, or as required for proper operation and for buried valves.
- 2. Non-rising stems:
  - a. Solid steel shafting with O.D. not less than O.D. of valve stem or galvanized steel pipe with I.D. not less than O.D. of valve stem.
  - b. Connected to the valve by a flexible socket coupling.
  - c. All other connections pinned, keyed, or socket.
- 3. Rising stems:
  - a. Stainless steel or carbon steel shafting with O.D. not less than O.D. of valve stem.
  - b. Bronze or stainless steel sleeves securely attached to stem.
  - c. Sleeve length and location to extend through each stem guide throughout the full vertical travel of the stem.
- 4. Stem guides:
  - a. Cast iron, bronze bushed, adjustable in 2 directions.
  - b. If extension stem length exceeds 120 inches or the weight exceeds 20 lb, provide a suitable thrust bearing to carry extension stem weight.
  - c. Maximum spacing:
    - 1) Non-rising stems: 100 times stem O.D.
    - 2) 10 feet max.
- 5. Buried valves:
  - a. Stem extend to within 6 inches of grade.
  - b. Provide spacers to center stem in valve box.
  - c. Provide 2" square wrench nut.
- 6. Operating stands:
  - a. Provide where indicated on Drawings or as specified.
  - b. Cast iron or fabricated steel.
  - c. Thrust bearing: Suitable to carry weight of extension stem.
  - d. Handwheel or lever as indicated on Drawings or as specified:
    - 1) Approximately 36 inches above floor.
    - 2) Handwheel minimum diameter: 8 inches.
  - e. Sleeve: Provide standard weight galvanized steel pipe for opening in floor beneath each operating stand.
- G. Valve boxes:
  - 1. Provide for all buried valves.
  - 2. Cast iron extension sleeve type with boxes and covers.
  - 3. Depth as required for valve.

- 4. Minimum diam: 5 inches.
- 5. Minimum thickness: 3/16 inches.
- 6. Box, cover, and base coated by dipping in asphalt varnish.
- 7. An appropriate word designating the valve service cast on cover.

## 2.02 MOTOR ACTUATORS— MODULATING AND OPEN/CLOSE SERVICE (VALVES 6 INCHES AND GREATER)

- A. Provide motor actuators where indicated on Drawings, for automated system operation or as specified for individual systems.
- B. Each motor actuator to consist of motor, gearing, handwheel, limit, and torque switches, hubricants, heating elements, wiring, terminals, and integral reversing controller constructed as a self-contained unit.
- C. Housing: Cast, weatherproof.
- D. Operating time from fully open to fully closed or the reverse for modulating valves: Adjustable from 15 seconds to two minutes.
- E. Motors:
  - 1. Mounted horizontally adjacent to or vertically above gearing.
  - 2. Do not mount with motor vertical below gearing.
  - 3. Totally enclosed, high torque, designed expressly for valve operator service.
  - 4. Capable of operating valve under full differential pressure for two complete open-close cycles without overheating.
  - 5. Designed in accordance with NEMA Standards.
  - 6. Insulation: Class F or better.
  - 7. Bearings: Permanently lubricated.
  - 8. Voltage tolerance:  $\pm 10$  percent.
  - 9. Voltage rating: 120 V, 60 Hz, 1 phase or 480 V, 60 Hz, 3 phase as required.
  - 10. Produce 1.5 times required torque.
- P. Gearing:
  - 1. All grease lubricated.
  - 2. Service factor: 2.0.
  - 3. Effectively sealed against entrance of foreign matter.
  - 4. AGMA nameplate not required.
  - 5. Designed to permit field ratio changes.
  - 6. Designed so motor comes up to speed before stem load is encountered in opening and closing direction.
  - 7. Conform to AWWA C540.
- G. Handwheel mechanism:
  - 1. Designed so handwheel doesn't operate during motor operation.

- 2. Designed so motor doesn't rotate when handwheel is rotated.
- 3. Provide declutching extensions to allow declutching of all electric actuators from floor level.
- 4. Actuator responsive to electrical power and control at all times, instantly disengaging handwheel.
- 5. Rotation: Counter clockwise to open.
- 6. An arrow indicating the open direction and the word "OPEN" cast on the handwheel.
- 7. Max force required: 80 lb.
- H. Torque switches:
  - 1. Provide opening and closing torque and thrust limit switches.
  - 2. Micrometer adjustment on each switch:
    - a. Reference setting indicator.
    - b. Variability 40 percent.
  - 3. Contact rating: 6 amp inductive at 120 V AC and 2.2 amp at 115 V DC.
- I. Geared limit switches:
  - 1. Space for 4 geared limit switch assemblies.
  - 2. Each assembly with 4 separate limit switches.
  - 3. Each assembly geared to driving mechanism and independently adjustable to transfer at any point between fully open and fully closed valve position.
  - 4. Contact rating: 6 amp inductive at 120 V ac and 2.2 amp at 115 V dc.
  - 5. Set limit switches as indicated on drawings.
  - 6. Provide 2 limit switch assemblies.
- J. Heating elements:
  - 1. Provide in motor and geared limit switch compartment.
  - 2. Rated 120 V ac.
  - 3. Continuously energized.
- K. Terminal facilities: Provide for connection to motor leads, switches, slide-wire type position transmitter, if required, and heating elements in geared limit switch compartment.
- L. Controller:
  - 1. Integrally mounted reversing motor starter in geared limit switch compartment.
  - 2. Motor overload protective device in each phase.
  - In 480 V. units, a control power transformer with fused and grounded 120 V secondary, with volt ampere capacity suitable for starter control plus continuous service to heater elements in motor housing and limit switch compartment.
  - 4. A nameplate of permanent type construction on the controller enclosure identifying the equipment controlled as with letters and numerals not less than 3/4 inch high.
  - 5. Mechanically and electrically interlocked.

- 6. Provided with the necessary direct operated auxiliary contacts for required interlocking and control.
- 7. Pilot devices:
  - a. In a weatherproof enclosure close coupled to actuator housing if actuator is easily accessible; if actuator is not easily accessible, locate pilot devices on nearby wall or mounting station.
  - b. Local Open-Stop-Close momentary push buttons.
  - c. Local-Off-Remote maintained selector switch.
  - d. Local Red "Open" and Green "Closed" indicating lights.
- 8. NEMA Size 1 minimum.
- 9. For modulating valves, provide manual-automatic switch and solid state modulator to receive 4-20 MA control signal and actuate valve to signaled position.
- M. Manufacturers:
  - 1. Modulating service:
    - a. Tyco/Keystone Series 77.
    - b. Limitorque Series L120.
    - c. Or accepted substitution.
  - 2. Open/Close service:
    - a. Tyco/Keystone Series 777 (EPI).
    - b. Limitorque Series L120.
    - c. Or accepted substitution.

# 2.93 MOTOR ACTUATORS—OPEN/CLOSE AND MODULATING SERVICE (VALVES 4 INCHES AND SMALLER)

- Provide motor actuators where indicated on Drawings, for automated system operation, or as specified for individual systems. Refer to Section 15100 for requirements for small diameter quarter-turn value actuators.
- B. Each motor actuator to consist of motor, gearing, limit switches, lubricants, heating elements, wiring, terminals, and integral reversing controller constructed as a self-contained unit.
- C. Housing: NEMA 4 die cast aluminum with baked-on powder coated epoxy.
- D. Motors:
  - 1. Thermal overload sensor.
  - 2. 50 percent duty cycle.
  - 3. Voltage rating: 120 V, 60 Hz, 1 phase.
  - 4. Produce 1.5 times required torque.
- E. Gearing: Hardened steel gear train.
- F. Lubrication: Gear train and drive components immersed in multipurpose grease suitable for service of 32 degrees F to 150 degrees F.

- G. Limit switches:
  - 1. 2 end of travel limit switches.
  - 2. Activated by independently adjustable stainless steel cams.
  - 3. Contact rating: 10 amp inductive at 120 V ac.
- H. Heating elements:
  - 1. Provide in motor and geared limit switch compartment.
  - 2. Rated 120 V ac.
  - 3. Continuously energized.
- I. Controller:
  - 1. Integrally mounted reversing motor starter.
  - 2. Motor overload protective device.
- J. Manufacturers:
  - 1. Limitorque LY Series, Model 1001 with Modutronic Position Control Package for modulating valves.
  - 2. Or accepted equal.

### 2.04 ACCESSORIES

- A. Limit switches:
  - 1. Adjustable mounting or fixed with adjustable cam.
  - 2. Totally enclosed contact rated 6 amp, inductive, at 120 V ac, minimum.
  - 3. End of travel or knee action as indicated on Drawings.

## PART 3 - EXECUTION

#### 3.91 INSTALLATION—GENERAL

- A. Install actuators in accordance with the manufacturer's instructions.
- B. Provide adequate support for all valve actuators to prevent damage or movement in pipe due to weight or torque of actuator.
- C. Furnish and install any adaptors or accessories needed to mate the valves and actuators furnished on the project.
- D. Install actuators such that position indicators are visible by standing on operations floor or from permanent platform.
- E. Valve control stations:
  - 1. Provide for all powered actuators.
  - Install where accessible by standing on operations floor or from permanent elevated platform.
  - If valve is not within reach or easily accessible by standing on operations floor or from permanent elevated platform, install remote valve control station at location acceptable to Engineer.

F. Provide minimum distances required from walls and other piping to center of valve to accommodate actuator dimensions and to facilitate maintenance of actuator. Immediately notify Engineer of all conflicts or discrepancies.

#### 3.02 ADJUSTMENTS

- A. Check and adjust valves and accessories for smooth operation in accordance with manufacturer's instructions.
- B. Powered Actuator: Adjust limit and torque switches as indicated on Drawings.

#### 3.03 FIELD QUALITY CONTROL

- A. Coordinate inspection of all valves by manufacturer's representative and instruct plant personnel on their operation and maintenance.
- B. Provide manufacturer's field services for valves with powered actuators and for other valves as required per Contract Documents.

### END OF SECTION 15090

#### SECTION 15905

# HVAC INSTRUMENTATION AND CONTROLS

### PART 1 - GENERAL

#### 1.01 SUMMARY

- A. Section Includes: This section covers the general requirements for the following:
  - 1. Furnishing and installing a complete, fully functional control system per this specification and the Construction Documents.
  - 2. Pre-assembled control panels.
  - 3. Actuators, thermostats, sensors, transmitters, thermowells, gauges, and mounting hardware as applicable.
  - 4. Control valves, dampers, linkages, and mounting hardware.
  - 5. Construction supervision.
  - 6. Startup and commissioning.
  - 7. Demonstration and training.
- B. Related Sections: Drawings and general provisions of the contract, including General and Supplementary Conditions, Division 1 Specification Sections, and Section 15500 apply to this section.
  - 1. Division 15 equipment and system sections with specific control requirements.
  - 2. Section 15990"Testing, Adjusting, and Balancing." for responsibilities and procedures of the TAB contractor.
  - 3. Division 16 sections for electrical equipment and wiring requirements and any electrical interface to the controls and instrumentation.
- C. Products Supplied, But Not Installed Under This Section:
  - 1. The automatic temperature control valves, separable wells for immersion sensors, and taps for flow and pressure instruments shall be provided by the Controls Contractor for installation by the Mechanical Contractor under the Controls Contractor's supervision.
  - 2. The Controls Contractor shall provide all automatic temperature control dampers, not provided by unit manufacturers, for installation by the Mechanical Contractor under the Control Contractor's supervision.

#### 1.02 DEFINITIONS

- A. It is the intention of these specifications and drawings to call for finished work, tested, and ready for operation. Wherever the word "provide" is used, it shall mean "furnish and install complete and ready for use."
- B. "Contractor" shall mean the Controls Contractor performing work under this Division of the Specifications.
- C. Where this specification states work to be performed by the words "shall" or "secure" or other performance functions, it shall be assumed that such work shall be performed by this Contractor unless stated otherwise.
- D. The word "Mechanical" applies to all work specified herein wherever applicable.

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E. The phrase "Architect/Engineer" implies that either may perform the task at hand.

## 1.03 - SYSTEM DESCRIPTION

- A. Design Requirements:
  - 1. Type of System: The automatic temperature control system shall be packaged Digital Controls for each piece of equipment with electric components as required.
  - 2. All digital and analog control loops shall be microprocessor (DDC) controlled unless otherwise shown on the Drawings.
  - Coordination: This Contractor shall interface with controls furnished with equipment. Provide additional control devices, interlock relays, and signal conditioners when necessary to accomplish specified sequences.
  - The system shall include all interlocks, field devices, wiring, piping, hardware, and software required to provide a complete, functional system in accordance with these specifications and drawings.
  - 5. Electrical wiring in connection with the automatic temperature control system, where shown on the Division 16 drawings, shall be performed by the Electrical Contractor. All other wiring required for proper operation of the automatic temperature system shall be performed by this Contractor.
  - Adjustments of manual balancing devices, as required to obtain design air and/or water tlows, shall be by the Balancing Contractor. The Controls Contractor shall provide assistance to the Balancing Contractor with control adjustments as required to obtain design flows by:
    - a. Providing on-site instruction on the proper interfacing and operation of their equipment
    - b. Providing the necessary software for use with the Balancing Contractor's personal computer for interfacing with their control equipment. Where proprietary software, equipment or gateways are required, this equipment shall be provided for the Balancing Contractor's use.
- B. Unless otherwise indicated, all equipment and performance data listed is for job site conditions.
- C. Drawings are not to be scaled.

#### 1.04 SUBSTITUTION APPROVALS

- A. Equipment and/or materials manufactured by any one of the manufacturers listed in this specification or on the drawings shall be acceptable.
- B. Where no specific manufacturer is listed, a first-class item of cataloged manufacture shall be furnished.
- C. Prior Approvals: Refer to Division 1, Substitutions.

#### 1.05 SUBMITTALS

A. Submit under provisions of Section 01330.

- B. Schedule: Submittal data and control drawings for all equipment and systems shall be submitted to the Architect/Engineer for review prior to ordering or fabrication of the equipment. The following information shall be included in these submittals:
  - 1. <u>30 Days or Less After Notice to Proceed</u>:
    - a. Control valve and damper schedules.
    - b. The valve and damper schedules shall also be submitted to the mechanical contractor for review by the piping and sheet metal contractors.
    - c. Product data for all products used in conjunction with the control system.
  - 2. 60 Days or Less After Notice to Proceed:
    - a. Control drawings.
    - b. Software information.
    - c. Test Plan and procedures.
  - 3. 60 Days or More Prior to Scheduled Stanup of the First Controlled System:
    - a. Software programming data.
    - b. Test plan and procedures.
  - 4. <u>10 Days or More Prior to Scheduled System Demonstration:</u>
    - a. Operational logs as described in Part 3.
    - b. Test plan with hardware and software testing results, calibration reports and technician certification.
  - 5. Upon Completion of Training Classes:
    - a. Videotaped record of all training.
    - b. One copy of all training materials.
- C. Shop Drawings:
  - 1. General:
    - a. Drawings shall be prepared using computer aided drafting that can produce files in the AutoCAD format.
    - b. The final or record drawings will become permanent record drawings and shall be prepared on 24" x 36", 4-mil Mylar.
    - c. Product data shall be in a three-ring binder. All product information shall be indexed and tabbed. The product data sheets shall be marked with the tag number as indicated by the drawings. All options, ranges and voltages that are to be provided shall be clearly indicated on each product data sheet.
    - d. Product data shall be submitted describing the operating systems associated with the DDC controllers and the workstations. Workstation software product data shall include information on the connectivity of the system using telephone and other supported means.

- 2. Valve and Damper Schedules:
  - a. Valve schedules may be included on the drawings or in the product data. The valve schedule shall include the following information:
    - 1) Valve tag number.
    - 2) System and service.
    - 3) Quantity, manufacturer and model number.
    - 4) Type (two-way or three-way).
    - 5) Fail Position.
    - 6) Body Size.
    - 7) Flow (gpm).
    - 8) Cv.
    - 9) Rangeability.
    - 10) Actual pressure drop.
    - 11) Close-off rating.
    - 12) Actuator model number.
    - 13) Spring range.
  - b. Damper schedules may be included on the drawings or in the product data. The damper schedule shall include the following information:
    - 1) Damper tag number.
    - 2) System and service.
    - 3) Quantity.
    - 4) Size.
    - 5) Manufacturer and model number.
    - 6) Fail position.
    - 7) Type (opposed, parallel).
    - 8) Actual pressure drop.
    - 9) Quantity of actuators.
    - 10) Actuator model number.
    - 11) Actuator spring range.
- 3. Drawings:
  - a. Drawings that cannot represent the total information on one sheet shall include appropriate match lines, cross-references and key plans. An example of this is a building floor plan.
  - b. The drawing package shall include:
    - 1) Cover sheet with a drawing index listing all included drawings.

- 2) A network diagram showing the network architecture and the une relationships of the panels on the network. This drawing shall include all network devices including; surge suppressors, lightning arrestors, repeaters, modems, gateways and routers. The power source, panel address, and physical location (room number) shall be shown for each device. Where external batteries or other power supplies are used they shall be shown on this drawing.
- 3) Control schematics and flow diagrams for each system monitored or controlled. These diagrams shall include:
  - a) A ladder diagram showing all wiring and pneumatic tubing associated with the controller. The location of the electrical power panel with breaker number shall be shown for all power sources.
  - b) Details showing the interconnection with motor starters, variable frequency drives and the associated bypass sections, chillers, boilers and other types of equipment. These details shall include wire numbers and terminal designations. The mounting locations of all control equipment shall be included.
  - c) A bill of materials shall be included with each control schematic. The bill of materials shall include the tag name used on the control drawing, description of the product, name of the manufacturer, complete model number, measurement range (if applicable) and quantity.
  - d) A complete input/output schedule for each DDC controller shall be included with each control schematic. The point name (the same one used in the software), and a functional description of the point shall be included in the I/O summary.
  - e) A sequence of operation shall be included with each control schematic. The sequence shall reflect actual programming, including all time delays and software interlocks. Copies of the sequence that appear in this specification are not acceptable.
  - f) Floor and roof plans showing the location of control panels, sensor, and mechanical equipment. The floor plans shall show the location of duct and space static pressure sample points.
- D. Software: Software submittal shall include the following:
  - 1. Point listings shall include all hardware and software points. A description of the point shall be provided. The default values of each point shall be shown.
  - 2. Program listings for each piece of controlled equipment shall be provided. The program listing shall be complete with all data required for controller operation.
  - 3. Submit a color printout of each graphic. The graphic shall show temperature, status, position and all data points that will appear on the screen. At the contractor's option, the graphics may be submitted on CD or disk provided that all required software for the display of the graphics is also furnished.
  - 4. A listing of all alarms and the alarm limits and time delays shall be provided.

- E. Quality Assurance/Control Submittals:
  - 1. Test Plan and Procedures: The test plan shall include the following:
    - a. Certification documentation for each hardware point. Certify that the point was tested and cycled to prove functionality. Include the calibration data, initial and final readings and the required offset.
    - b. Procedures for the seven-day test.
    - c. Certification documentation for software sequence of operation.
    - d. The test plan shall be coordinated with Section 15990 "Testing, Adjusting, and Balancing" Contractor.
- F. Closeout Submittals:
  - 1. Project Record Documents:
    - a. Upon completion of the installation, provide a complete set of record (as-built) drawings on a clear and legible set of Mylar transparencies. The content and format of the drawings shall be as described previously.
    - b. Prior to final completion of the installation, prepare complete Operation and Maintenance (O&M) manuals. Refer to Division 1. Section 01300, and Division 15, Section 15500, for requirements. Also provide one set of CAD-prepared drawings in AutoCAD. Format shall be .DWG files.
      - 1) Assist Division 15 Contractor in preparation of a simplified description of the operation of all systems including the function of each piece of equipment within each system. These descriptions shall be supported with a schematic flow diagram when applicable.
      - 2) Temperature control diagrams including an explanation of the control sequence of each system along with the following instruction wherever applicable.
        - a) Emergency procedures for fire or failure of m ajor equipment.
        - b) Normal starting, operating, and shutdown.
        - c) Summer or winter shutdown.
    - c. The temperature control diagrams are to be wall-mounted under glass (or in plastic) in an accessible location, preferably in the main mechanical equipment room.
    - d. Control System Programmer's manual with complete description of the custom control language and associated editor, including sample-written programs. Provide complete sets of all programming forms, applications memorandums, and addenda to the programmer's manual. All software and firmware algorithms shall be completely described and documented.
    - e. Maintenance, installation, and engineering manual(s) that clearly explain how to debug hardware problems; how to repair or replace hardware; preventative maintenance guidelines and schedules; calibration procedures: and how to engineer and install new points, panels, and operator interfaces.

- f. Documentation of all software: List separately all software parameters that may need updating by the Owner, such as, though not limited to, daily start/stop schedules; setpoints; alarm points; control loop cascade, and PID parameters, etc.
- g. All programs, code, databases, graphic files, CAD drawings, and symbol libraries generated for operation of the system shall be included as part of the system documentation. This information shall be submitted both in hard copy bound format and electronic format.
- Input/output schedules, data sheets, and all other items required. Describe all regular maintenance that will need to be performed on the DDC hardware. Provide list of recommended spare parts. List all replacement parts with part numbers.
- Complete original issue documentation, installation, operation manuals, and supporting software for all third-party hardware and software furnished and installed as part of the system or required for the operation of the system, including remote terminals, user's computer workstation, monitors, graphics and memory boards, network servers, printers, and modems.
- j. All software licenses, warranty certificates and documentation for all hardwate and software including third party hardware and software shall be provided.
- k. All testing, startup, calibration and checkout reports and checklists.
- 1. A list of recommended spare parts with part numbers and supplier.
- m. Recommended preventive maintenance procedures for all system components including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions.

# 1.06 QUALITY ASSURANCE

- A. Qualifications:
  - 1. Approved Controls Manufacturers and Installing Contractors:

a.	Honeywell.	Factory branch office.
Ե.	Johnson Controls.	Factory branch office.
c.	Stemens Building	Factory branch office.

- 2. Manufacturers not listed in item A above may request approval by submitting a proposal at least 30 days prior to bid date. The proposal shall include the information listed below.
  - a. A listing of all personnel that will be assigned to this project, their position, and a resume of experience.
  - b. An analysis of compliance to this specification. Indicate for each paragraph compliance or exception. If the product or service does not completely match the requirements, indicate exception and describe fully the area(s) of deviation and their impact on system functionality. This analysis shall be presented in the opposing page format. The specification shall be presented on one page with the compliance or exception described on the opposing page.
  - c. A sample of the as-built documentation for a project of similar magnitude. This sample shall include items specified in Section 15905 insofar as possible.

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- d. A list of references with project descriptions for five local installations of similar scope and magnitude. Include contact names and phone numbers for an operating engineer, facility manager and the consulting engineer for each reference.
- B. Regulatory Requirements: Refer to Section 15500 for general code, standard, and regulatory requirements.
- C. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner's representative in writing. This requirement is not intended to restrict the Contractor to the use of outdated equipment.
- D. All products used in this installation shall be new and currently under manufacture. Spare parts shall be available for at least five years after completion of this contract.

### 1.07 WARRANTY

- A. Refer to Section 15500 for general warranty requirements.
- B. Special Warranty:
  - 1. The warranty period shall begin as authorized by the Owner's representative in writing. Completion shall not occur before the Contractor has performed the tests required in Article 3.
  - 2. The control system shall be warranted to be free from defects in material and workmanship and in software design and operation for a period of one year after completion of the contract. The Contractor shall provide the necessary skills, labor, and parts to ensure that all system and component failures are promptly repaired. This warranty shall become effective starting on the date of completion.
  - 3. The Contractor shall receive calls during the warranty period for all problems or questions experienced in the operation of the installed equipment and shall take steps to correct any deficiencies that may exist. The response time to critical problems shall be four (4) hours maximum.
  - 4. The Contractor shall maintain a backup of all software installed in the system. The backup shall be updated monthly or whenever a change to the software is made. A reload of backup software into the system shall be performed by the Contractor immediately upon notification by the Owner. The reload shall be free of charge unless it is due to a power failure of a duration longer than the battery backup.
  - 5. The Contractor shall optimize all control software to ensure acceptable operating and space conditions and peak energy efficiency. This shall include changes needed to optimize operation of the systems even if not explicitly described in Control Strategies.
  - 6. The Contractor shall provide and install at no extra cost all hardware, firmware, and software updates released prior to and during the warranty period. These updates shall be installed and fully implemented on every device to which they apply, throughout the project. Written authorization by the Owner must be obtained prior to the installation of these changes.
  - 7. At the end of the warranty period, the Contractor shall supply updated copies of the latest versions of all project record documentation as described above in Project Record Documents. This includes final updated drawings, software documentation, and magnetic media backups that include all changes that have been made to the system during the warranty period.

### 1.08 DEMONSTRATION AND TRAINING

- A. This Contractor shall provide a minimum of eight hours of system and control demonstration time at the job site for the Owner's personnel.
- B. This Contractor shall provide at least 12 hours of classroom training sessions at times and location as directed by the Owner. The training shall focus on design, operation, and maintenance procedures of the products installed and shall cov er:
  - 1. Hardware configuration including PC boards, switches, communication and point wiring, and location of all sensors and control devices.
  - 2. Hardware maintenance, calibration, troubleshooting, diagnostics, and repair instructions.
  - 3. Operation of central workstation, including logging on and off, interrogating the system, producing reports, acknowledging alarms, overriding computer control, changing firmware and software parameters, and generating and linking graphic screens.
  - 4. The operational sequence of each system including normal and abnormal operating modes, operating control strategies, and operator actions required to reset or monitor the system.
  - 5. Programming, using the editor, program design. syntax. compiling, and loading of custom control software.
  - 6. Recovery procedures from power failures.
  - 7. Alarm formats and assignment.
  - 8. Maintaining software and programming backups.
- C. The instructor(s) for the above sessions shall be employee(s) of the control Contractor whose primary function is customer training and applications support.
- D. Provide the Owner with a complete video (digital format) of all demonstration and training sessions conducted under this section.
- E. The training may be phased. Owner may elect to conduct training in four-hour sessious over the life of the warranty period. The full compliment of instructional material shall be available to each employee at each training session up to a maximum of ten (10) individuals.

# 1.09 OWNERSHIP OF PROPRIETARY MATERIAL

- A. All project-developed software and documentation shall become the property of the Owner. The Owner shall retain the right to duplicate and/or modify such for use at this facility. These documents shall not be copyrighted. These include but are not limited to:
  - 1. Project graphic images.
  - 2. Record drawings.
  - 3. Project database.
  - 4. Job-specific application programming code.
  - 5. All project specific documentation.

# PART 2 - PRODUCTS

# 2.01 MANUFACTURERS

A. DDC system shall be by Honeywell, Johnson Controls, or Siemens Building Technologies.

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- B. Electric control devices shall be manufactured by Honeywell, Johnson Controls, Siemens Building Technologies, or SIEBE.
- C. Regardless of the manufacturer, the specific products and design chosen shall meet the requirements of this specification.
- D. Electric actuators shall be UL listed as manufactured by Belimo, Honeywell, Johnson Controls, Siemens Building Technologies, or SIEBE.

#### 2.92 CONTROL WIRING

- A. Cables shall be shielded when so recommended by manufacturer. Conductor size shall be in accordance with manufacturer's recommendations subject to specified minimum size. See Part 3 for allowable types.
- B. All low-voltage cables in ceiling plenums, not in raceway, shall be UL listed for air plenum service.
- C. All insulated wire to be copper conductors, UL labeled for 90 °C minimum service.
- D. Raceway for wiring shall be per Division 16.

#### 2.03 TRANSIENT VOLTAGE PROTECTION

- A. TVSS surge protectors, for incoming 120 VAC power to controllers: Leviton 51020WM, or equal. Surge protectors furnished shall be UL 1449 listed. The maximum single-pulse transient current shall be 26kA, noise rejection at 50 ohms -40 to -50 for 5K to 100mhz, the cat B3 combination wave peak clamping voltage shall be L-N 300 V, L-G 350 V, the UL 1499 ratings shall be L-N330V, L-G 400V, Fault current rating (AIC rating assigned per UL) shall be 5,000A.
  - 1. Transient voltage protection for all twisted pair, telephone and coaxial data communication lines between controllers shall be per manufacturer recommendations. Provide all required repeaters to ensure signal integrity.
  - 2. Lightning arrestors on all communications and other lines that exit the building shall be per manufacturer recommendations.

### 2.04 CONTROL DAMPERS

- A. Motorized control dampers, unless otherwise specified elsewhere, shall be as follows:
  - 1. Control dampers shall be parallel or opposed blade type as below or as scheduled on drawings.
    - a. Outdoor and/or return air mixing dampers and face and bypass (F&BP) dampers shall be combination parallel/opposed blade, approximately 57% OB, arranged to direct air streams towards each other. Ruskin CD 403 type or equal.
    - b. Other modulating dampers shall be opposed blade type.
    - c. Two-position shutoff dampers may be parallel or opposed blade type with blade and side seals.
  - 2. Damper frames shall be built to the structural equivalent of 13-gauge steel channel and shall be galvanized or extruded aluminum with reinforced corner bracing.
  - Damper blades shall not exceed 8 inches in width or 48 inches in length. Blades are to be suitable for medium velocity performance (2,000 fpm). Blades shall be not less than 16 gauge.

- 4. Damper shaft bearings shall be oil impregnated bronze or stainless steel.
- 5. All blade edges and top and bottom of the frame shall be provided with replaceable butyl rubber or neoprene seals. Side seals shall be spring loaded stainless steel. The blade seals shall provide for a maximum leakage rate of 10 cfm per square foot at 4 inches w.c. differential pressure. Pressure drop shall not exceed 0.10 inch w.c. at a wide-open face velocity of 1,500 fpm. The dampers shall have triple V type blades.
- 6. Individual damper sections shall not be larger than 48" x 60". Provide a minimum of one damper actuator per section.
- 7. Dampers shall have exposed linkages. Dampers with exposed gear linkages are not acceptable.
- 8. Ruskin or equal.

# 2.05 LOCAL CONTROL PANELS

- A. All indoor control cabinets shall be fully enclosed NEMA 1 construction with hinged door, key-lock latch, baked enamel finish, removable subpanels, wall-mounted or freestanding. All temperature control panels on the project shall be keyed alike.
- B. All outdoor control cabinets shall be fully enclosed NEMA 12 construction with hinged door, external key-lock latch, baked enamel finish, removable subpanels, wall-mounted or freestanding. All temperature control panels on the project shall be keyed alike.
- C. Panels shall house the microprocessor, communication interface, all controllers (except those required at VAV boxes), relays, indicators, transmitters, switches, pilot lights, override timers, etc., to allow quick access for adjustment and troubleshooting.
- D. Manual switches and indicating devices shall be flush-mounted ou panel face. Provide engraved plastic or lithographed metal nameplates for all items on the panel face.
- E. Internal components shall be securely mounted on removable subpanels. Each component shall be individually labeled with function and device identification, as shown on control/interlock shop drawings.
- F. Interconnections between internal and face-mounted devices prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminal blocks shall be provided for all field connections, and shall be UL listed for 600-volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring.
  - 1. Control terminations for field connection shall be individually identified per control drawings.
  - 2. All internal wiring between panel mounted devices and field terminal blocks shall be marked on both ends with the appropriate identifying tag.
- G. Provide on/off power switch with over-current protection for control power sources to each local panel.
- H. Provide Ethernet connection at each main DDC panel in each mechanical room.

### 2.06 CONTROL DEVICES - ELECTRIC

- A. Room Thermostats:
  - 1. All wall-mounted room thermostats or sensors shall have locking covers with concealed setpoint adjustment. Omit thermometers when possible.
  - 2. Line voltage thermostats shall be UL listed, SPDT, SPST, or DPST with contact rating suitable for application, maximum 2°F differential.
  - 3. Low voltage thermostats shall be single or multi-stage heating and/or cooling type as required by application.
    - a. Combination heating/cooling thermostats shall have independent adjustments for heating and cooling setpoints and shall not allow setpoint crossover.
    - b. Provide individual heat or cooling anticipator for each control stage. Anticipator shall be matched to connected load, or shall be adjustable.
    - c. Suitable switch sub-bases shall be provided when required by application, with switch functions clearly identified by permanent labels. Field-applied "stick-on" labels are not acceptable.
    - d. Microprocessor-based programmable type thermostats, when used, shall not lose time or program on power failures of 12 hours or less.
  - 4. Provide scale ranges (minimum) with locking type stops for various applications as follows:
    - a. Heating Occupied areas: range 55-85°F, 72° max. stop.
    - b. Cooling Occupied areas: range 55-85°F, 75° min. stop.
  - 5. Provide metal guards with security screws for all thermostats located in public areas such as lobbies, corridors, gyms, cafeterias, etc.
- B. Duct, Immersion, and Outdoor Thermostats:
  - 1. Provide single or multistage type with contact arrangement and rating suitable for application. Line voltage units shall be UL listed.
  - 2. Sensing element shall be liquid-filled remote bulb type or bi-metal type as required.
    - a. Remote bulb type shall have sufficient capillary lengths to allow mounting of thermostat at convenient location for adjustment.
    - b. Provide separable wells for immersion applications.
    - c. Provide sun shields for outdoor sensing bulbs.
    - d. Provide ambient temperature compensation where thermostat body is subjected to outdoor ambient temperature variations.
  - 3. Individual stage differential -2°F maximum (fixed). Provide adjustable differential type when thermostat is used for capacity control of DX refrigeration or to cycle fans.

# 2.07 SOLID-STATE SENSING DEVICES

A. Temperature sensors shall be thermistor (10K or 20K), or platinum RTD type (100-ohm wire wound, or 1,000-ohm, thin film. Accuracy shall be ±0.5°F with stability of 0.25°F over five years. Sensors used for BTU calculations shall be accurate to  $\pm 0.2^{\circ}$ F or 1% of span, whichever is less.

- 1. Space (room) sensors shall be surface-mounted in a suitable protective enclosure. Space sensors serving VAV boxes or duct heating coils shall have a setpoint adjustment. VAV terminal sensors shall have a network connection jack. Covers shall be blank, without any company logos. Provide insulating mounting base on all sensors on exterior walls.
- 2. Duct and immersion sensors shall be immune to moisture and shall have a junction box for electrical connections. Sensing element shall be suitable for the application.
  - a. Provide averaging elements for mixed air applications.
  - b. Provide separable wells and insulation extension for immersion applications.
  - c. Provide sun shields for outdoor sensors.
- B. Thermowells for all immersion sensors shall be brass or stainless steel as recommended by manufacturer for the application. They shall have 1/2-inch or 3/4-inch external NPT threads and shall provide for extension of sensor electrical junction box on insulated pipes.
- C. Carbon Dioxide sensor: Unit shall have a non-dispersive infrared (NDIR) detection cell, 0-2,000ppm measurement range, adjustable span, automatic electronic zero, ±75 ppm annual drift, ±20 ppm repeatability and 5% accuracy. Unit shall require calibration not more than annually, shall have 4-20 ma analog output, high limit N.O. alarm relay, 4-digit digital display, and duct sampling tubes for duct-mounted applications. Provide calibration kit. Kele CD-1 or equal.

### 2.08 TRANSMITTERS - SOLID-STATE

- A. Transmitters shall have sensing elements suitable for application.
- B. Transmitters shall have direct-acting, linear output signal compatible with controller, with full scale accuracy as described below. Zero and span shall be field-adjustable.
  - 1. Transmitter range (span) shall be suitable for application, typically as follows:
    - a. Static Pressures:
      - 1) Building S.P. -0.1 inch to +0.1 inch w.g.
      - 2) Supply duct S.P. 0 inch to 3 inch w.g. or 1.0 inch to 4 inch w.g.
      - 3) Water pressure. 0 to 100 psig.
      - 4) Water differential pressure 0 inch to 300 inch w.g.
  - 2. Transmitter sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage.

#### 2.09 AUXILIARY DEVICES - ELECTRIC

- A. Damper end switches shall be UL listed, line voltage SPDT snap-acting, pilot duty rated (125 VA minimum) NEMA 1 enclosure, with roller type actuating arm suitable for damper position application.
- B. Water pressure switches shall be diaphragm operated with fully adjustable setpoint. Switch shall have visible set point indicator. Unit shall have 316 SS diaphragm. Operating range shall be as required by the process. United Electric series 490 or equal.

- C. Control relays shall be UL listed plug-in type with dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage suitable for application. Idee series RH-L, ULAC or equal. Provide diodes to limit back EMF on all DC relays and MOVs on AC.
- D. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable plus or minus 200% (minimum) from setpoint shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide NEMA 1 enclosure when not installed in local control panel. Seimens series CK or equal.
- E. Control transformers shall be UL listed. Class 2 current-limiting type, or shall be furnished with overcurrent protection in both primary and secondary circuits for Class 2 service.
- F. Manual control switches shall be UL listed for use in NEMA 1 enclosures with contact arrangement and rating suitable for application. Bat handle or knob actuator with nameplate clearly identifying function of each switch position.
- G. Current-operated switches shall be self-powered, solid state split core with manually adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system. Where used in conjunction with variable frequency drives the current operated switch shall be recommended for such service by the manufacturer. The Current switch shall have a maximum hysteresis of 0.01A in the 1.5A to 6 amp range. Manufacturers: Neilsen-Kuljian, Veris Industries or equal.
- H. Current transducers shall be 4-20 ma output solid state with ±0.5% of full scale accuracy. Unit shall have reverse voltage protection, and a flat frequency response from 20 to 100 Hz. The range shall be selected to meet the application. Manufacturers: Neilsen-Kuljian AT-420, Veris Industries Hawkeye 720, or equal.
- 1. Power Supplies:
  - 1. Unit output shall match the required output current and voltage requirements. Current output shall allow for a 50% safety factor. Output ripple shall be 3.0 MV maximum P-P. Regulation shall be 0.10% line and load combined, with 50-microsecond response time for 50% load changes. Unit shall have built-in over voltage protection.
  - 2. Unit shall operate between 0°C and 50°C. EM/RF shall meet FCC Class B and VDE 0871 for Class B, and MIL Standard 810C for shock and vibration.
  - 3. Unit shall be UL recognized.
  - 4. Sola or equal.

### 2.10 ACTUATORS AND POSITIONERS - ELECTRIC

- A. Externally mounted damper actuators
  - 1. Electronic direct-coupled actuation shall be provided.
  - 2. The actuator shall be direct-coupled over the shall, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assembly shall be of a "V" bolt design with associated "V" shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage.

Spring return actuators shall have a "V" clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or set screw type fasteners are not acceptable.

- 3. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
- 4. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.
- 5. All spring return actuators shall be capable of both clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
- 6. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control input and provide a 2 to 10 VDC or 4 to 20 mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is acceptable. All actuators shall provide a 2 to 10 VDC position feedback signal.
- All 24 VAC/VDC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC or more than 5 watts for DC applications. Actuators operating on 120 VAC power shall not require more than 10 VA. Actuators operating on 230 VAC power shall not require more than 11 VA.
- 8. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque capacity shall have a manual crank for this purpose.
- 9. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.
- Actuators shall be provided with a conduit fitting and a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
- 11. Actuator size and rating shall be suitable for intended application.
- 12. Damper actuators shall be selected per manufacturer's recommendations to provide sufficient close-off force to effectively seal damper. Modulating actuators shall provide smooth modulating control under design flow and pressure conditions. Furnish a separate actuator for each damper section.
- 13. Actuators shall be Underwriters Laboratories (UL) Standard 873 listed.
- 14. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty. Manufacturer shall be IS09001 certified. Actuators shall be as manufactured by BELIMO or equal.
- B. Valve and internally mounted damper actuators:
  - 1. Electric actuators shall be either push-pull magnetic, hydraulic, direct coupled or rotary (gear-train) type for two-position or modulating service as required by application. All electric actuators shall be UL listed with NEMA 1 enclosures, unless otherwise specified.
  - 2. Actuators shall be permanently lubricated; gear-train units shall be oil-immersed type or shall have permanently lubricated high-density polymer gears.

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- 3. Actuator housings shall be of sturdy construction.
- 4. Ambient temperature range shall be at least 40° to 120°F, except actuators subjected to outdoor ambients shall have ambient range of -20° to 125°F minimum.
- 5. Input signal requirements and voltages compatible with controller output signals.
- 6. Actuator size and rating shall be suitable for intended application.
- 7. Damper actuators shall be selected per manufacturer's recommendations to provide sufficient close-off force to effectively seal damper. Modulating actuators shall provide smooth modulating control under design flow and pressure conditions. Furnish a separate actuator for each damper section.
- 8. Valve actuators shall provide tight close-off at design system pressure. Modulating actuators shall provide smooth modulation at design flow and pressure conditions.
- 9. Actuators shall have a spring return to fail to the safe position as indicated on the drawings. Actuators relying on batteries are not acceptable.
- 10. Approved manufacturers/models are:
  - a. Honeywell M600, M700, M800, M900 series.
  - b. Johnson M100 series, DA3000 series.
  - c. Belimo.
  - d. Siebe.
- C. Electric actuators for ball Valves shall be 24 VAC electronic proportional spring return with input and feedback output signals of 2 to 10 VDC. Actuator shall rotate 95° in 150 seconds or less and shall spring return to normal closed position in 20 seconds or less on power failure. Actuator shall have hex crank manual override.
  - 1. Actuators and all accessories shall be provided by the valve manufacturer and shall be factory-mounted and aligned to the valve body.
  - 2. Actuators shall include weathertight covers when located outdoors.
  - 3. Belimo or equal.

### 2.11 SAFETY CONTROLS

A. Low Temperature Limit Safety Controller: Shall be UL listed, manual reset type, with 20foot, non-averaging elements and auxiliary contacts for alarm purposes. Any one foot of element sensing temperature below setpoint shall trigger fan shutdown. Provide one Low Temperature Limit Safety Controller for each coil section of each coil bank (e.g., one coil with three sections requires three Low Temperature Limit Safety Controllers). Wire Low Temperature Limit Safety Controller to protect unit in both hand and automatic operation.

### PART 3 - EXECUTION

### 3.01 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started. B. The contractor shall inspect the site to verify that equipment can be installed as shown, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

### 3.92 CONTROL WIRING

- A. All control and interlock wiring shall comply with the national and local electrical codes and Division 16 of these specifications. Where the requirements of this section differ with division 16 the more restrictive requirements shall take precedence. Control wiring shall be concealed except in equipment rooms.
- B. All Power (line voltage) and Class 1 wiring shall be UL listed in approved raceway per NEC and Division 16 requirements.
- C. All Power limited circuits (Class 2 or Class 3) shall also be in metal raceway, except as follows:
  - 1. Concealed and accessible locations including ceiling return air plenums: Approved cables not in raceway may be used provided that:
    - a. Circuits meet NEC Class 2or Class 3 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 or Class 3 current-limit.)
    - b. All cables shall be UL listed for application, i.e. Cables used in ceiling plenums shall be UL listed specifically for that purpose.
- D. Approved Cables not installed in raceways shall be subject to the following :
  - 1. Install wiring in sleeve where wiring passes through walls and floors. Maintain the fire rating (if any) at all penetrations.
  - Cables shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical conduits, or ceiling suspension systems. All plenum cable and installation shall comply with the requirements of the NEC.
  - 3. Network data cables shall be identified with permanent labels installed every 12 feet.
  - 4. Exposed splices shall not be permitted. Cable shall be installed without splices between terminal points.
  - 5. Maintain a minimum of 6 inches from high temperature equipment (e.g., steam pipes, flues, etc.).
- E. All cable conductors shall be minimum 18 AWG stranded, except 19 AWG may be used for home runs to central control panels, and minimum 22 AWG, twisted pairs for resistance type sensors and/or data communication cables. Cables shall be shielded when so recommended by the manufacturer. Line voltage power and interlock wiring conductors shall be THHN, 14gauge minimum. Size wire in accordance with NEC.
- F. All wiring shall be installed as continuous lengths with no splices permitted between termination points.
- G. All control wiring shall be installed in a neat and workmanlike manner parallel to building lines with adequate support. Install without splices between terminal points.
- H. This Contractor shall terminate all control and/or interlock wiring and maintain updated (asbuilt) wiring diagrams with terminations identified at the job site.

- I. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3 feet in length and shall be supported at each end. Flexible metal conduit less than 1/2-inch electrical trade size shall not be used. In areas exposed to moisture, liquid-tight, flexible metal conduits shall be used.
- J. Provide conduit seal-offs where portions of an interior raceway system pass through walls, ceiling or floors that separate adjacent rooms having substantially different maintained temperatures or when a raceway goes from indoors to outdoors.
- K. Wiring for analog inputs shall not be run in conduit containing 120 VAC wiring or any wiring that carries switched signals or any noise-generating sources.
- L. Follow manufacturer's installation recommendations for all communication and network cabling. Network or communication cabling shall be run separately from other wiring. When plenum cable is not allowed, network or communication wire shall be installed in a dedicated raceway. Other wiring in communications raceway is not allowed.

## 3.03 TRANSIENT VOLTAGE PROTECTION

- A. This Contractor shall provide and install:
  - 1. Transient voltage protection, on all incoming 120 VAC power to all controllers (except VAV controllers).
  - 2. Transient voltage protection for all twisted pair, and coaxial data communication lines between controllers. Provide all required repeaters to ensure signal integrity.
  - 3. Transient voltage protection on all phone lines.
  - 4. Lightning arrestors on all communications and other wiring that exit the building. Locate the arrestor at the point of building entrance.
  - 5. Provide ground connection sized and installed in accordance with the manufacturers instructions.

# 3.84 CONTROL DEVICE LOCATIONS

- A. Room thermostats and sensors shall be mounted 44 inches from the finished floor to the center of the device for ADA Compliance.
- B. Outdoor temperature sensing bulbs and sensors shall be located on north exposure, in shaded location when possible, unless shown otherwise. Provide sun shield for temperature sensors.
- C. Remote control devices not in local panels shall be accessible for adjustment and service below 6 feet above the finished floor whenever possible.
- D. Averaging type sensing elements shall be firmly supported in ductwork or air handling unit. The element shall serpentine vertically across the duct or plenum. Each bend shall be affixed with copper capillary clips installed with sheet metal screws. Spans of ten feet or more shall be supported at ten foot or less intervals to conduit mounted horizontally within the duct. The conduit shall be rigidly affixed at each end and the sensor shall be attached to the conduit using plenum-rated tie wraps. Do not wind averaging elements around conduit.
- E. Low temperature limit sensing elements shall be firmly supported in ductwork or air handling unit. The element shall serpentine horizontally across the coil face. Each bend shall be affixed with copper capillary clips installed with sheet metal screws.
- F Provide thermal conducting compound for all sensors in thermowells.

- G. Locate all control devices wired by the Electrical Contractor under Division 16.
- H. All analog pressure and differential pressure transmitters for air service shall be located in the DDC control panels. Mounting air pressure transducers at the ductwork is not acceptable.
- I. Seal the wall opening and wire penetration of all wall mounted temperature sensors to prevent airflow from the wall cavity, from affecting the sensor reading.

### 3.05 CONTROL PANELS

- A. Field wiring to panels shall be enclosed in metal raceway.
- B. Panels shall be mounted at eye level for accessibility and service.
- C. Local control panels shall be located within 50 feet of system served unless otherwise shown on plans.
- D. Mount panels on solid non-vibrating surfaces in areas free from moisture or water accumulation. Where such surfaces are not readily accessible, mount the panel on rigid unistrut stand attached to the floor. The sides of ducts and air handling units are not acceptable mounting surfaces.
- E. Control devices shall be installed in panels. Control and status relays are to be located in designated enclosures only. These relays may also be located within packaged equipment control panel enclosures. Control relays shall not be located within Class 1 starter enclosures. At the contractor's option, the relays may be installed in the same enclosure as the controller.
- F. VAV controllers shall be installed in metal enclosures with a removable cover. The VAV controller number shall be labeled on the outside of the enclosure. Where permitted in other sections of this specification, plenum cable may directly enter the enclosure if a plastic bushing is provided.

### 3.96 FIELD DEVICE INSTALLATION

- A. Actuators: Mount and link control damper actuators per manufacturer's instructions.
  - 1. To compress seals when spring return actuators are used on normally closed dampers, power actuator to approximately a 5 degree open position, manually close the damper, and then tighten the linkage.
  - 2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
- B: Flow Switch Installation: Coordinate installation with other contractors to comply with the following:
  - 1. Install using a Thread-O-Let in steel pipe. In copper pipe use C x C x F Tee, no pipe extensions or substitutions allowed.
  - 2. Mount thread-o-let a minimum of 5 pipe diameters up stream and 5 pipe diameters downstream or 2 feet, whichever is greater, from fittings and other obstructions.
  - 3. Cut hole in pipe with hole saw, clean and deburr surfaces. Hole diameter shall be in accordance with flow switch instructions.
  - 4. Install in accordance with manufacturer instructions.
  - 5. File paddle edges as required to clear thread-o-let and pipe.
  - 6. Use correct paddle for pipe diameter.

- 7. Assure correct flow direction and alignment.
- 8. Mount in horizontal piping flow switch on top of the pipe.
- 9. Use thread-locking compound on paddle screw.
- 10. Adjust flow switch in accordance with manufacturer instructions.

### 3.07 IDENTIFICATION

- A. All control equipment shall be clearly identified by control shop drawing designation as follows:
  - 1. Control valves -- brass tags.
  - Other remote control devices and sensors: metal tags; plastic laminate labels; or, on uonporous surfaces only, permanent label tape as produced by the Brother "Easy Touch" label maker. Do not attach tag or label to removable covers, etc. Rivet or stick to device or adjacent surface.
  - 3. Control panel doors engraved nameplate with panel number and systems served.
  - 4. Devices in control panels: engraved plastic tags; metal tags; or, on non-porous surfaces only, permanent label tape as above, mounted to panel adjacent to control device. 1/4inch high letters minimum
  - 5. All wiring, including wiring within factory-fabricated panels, shall be labeled within 2 inches of termination with DDC point number/controller number or other descriptive information.
  - 6. All metal and plastic engraved labels shall be secured with chains, nylon tie-wraps, or rivets. Screws with exposed threads are not acceptable. Permanent adhesive is acceptable only when mechanical fasteners would damage the labeled equipment.
  - 7. All switches, relays, and panel components shall be labeled. Relays shall be labeled such that removal of the relay does not move the label.
  - Raceway identification: For ease of identification, junction and pull box covers shall be color-coded. Coordinate the color of the junction box covers with Division 16 and the Owner.

## 3.08 **PROTECTION**

- A. The Contractor shall protect all work and material from damage by his work or workmen, and shall be liable for all damage thus caused.
- B. The Contractor shall be responsible for work and equipment until finally inspected, tested, and accepted; he shall protect work against theft, injury, or damage; and shall carefully store material and equipment received on site that is not immediately installed. He shall close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

### 3.09 CLEANUP

A. At the completion of work, all equipment provided by this section shall be checked and thoroughly cleaned including under equipment and any and all other areas. Clean exposed surfaces of all equipment and panels of all grease, plaster, or other foreign material. Remove all stick-on labels and clean surfaces.

- B. At the completion of the work, remove from the building, the premises, and surrounding streets, alleys, etc., all mbbish and debris resulting from work performed under this section and leave all equipment spaces absolutely clean and ready for use.
- C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet, jacket, or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

### 3.10 TESTING

- A. Prior to substantial completion, the control system shall undergo a series of tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed their own performance tests.
- B The tests described in this section are to be performed in addition to the tests that the Contractor performs as a necessary part of the installation, startup, and debugging process. Control system testing shall be coordinated with the Commissioning Contractor and scheduled with the Owner's representative.
- C. The Contractor shall provide at least two men equipped with two-way communication, and shall test actual field operation of each control and sensing point for all modes of operation including day, night, summer, winter, occupied, unoccupied, fire/smoke alarm, and power failure modes. The purpose is to test the calibration, response, and action of every point. Any test equipment required to prove the proper operation shall be provided by and operated by the Contractor. The Commissioning agent and the Owner's Representative (at their discretion) may observe and review these tests.
  - The system software shall be complete such that each control loop shall function as specified in the Sequence of Operation. This contractor shall be required to furnish the software program and test the operation of every branch and control loop.
  - 2. This contractor shall be responsible for all necessary revisions to the software as required to provide a complete and workable system consistent with the letter and intent of the specification. Control performance criteria is specified in the sequence of operations.
- D. A point to point verification shall be made for each input and each output to the system. The check shall include the operator workstation such that the correct point assignment at the workstation is also verified. The calibration of all input and output points shall be tested, documented and adjusted as needed.
- E. The operation of each hardwired safety and interlock shall be tested. This testing shall verify the correct operation of the safety or interlock in the hand and automatic modes of operation.
- F. Each alarm shall be tested. The receipt of the correct alarm message shall be verified for each alarm and device receiving the alarms. Dial out alarms shall be verified.
- G. Power failure restart and software back up during power failure shall be tested.
- H. Demand limiting (where used): The contractor shall supply trend data output showing the action of the demand-limiting algorithm. The interval selected shall cover a time period when load shed is active. The data shall document the action on a minute-by-minute basis over at least a one-hour period. Included in the trend shall be building KW, demand limiting scipoint, and the status of sheddable equipment outputs.

- I. Operational logs for each system that indicate all setpoints, operating points, valve/dauper positions, mode, and equipment status shall be submitted to the Architect/Engineer. These logs shall cover a 48-hour period and have a sample frequency of not more than ten minutes. The data collection start time and sample frequency shall be the same for each point on a given system. Outdoor air temperature and humidity shall be included with each log. Digital points shall indicate the on condition as 100% and the off condition as 0%. The logs shall be provided in graphical format with sufficient resolution to see the ten-minute data intervals. All points associated with a system including start and status points shall be included on the same graph. The logs shall also be submitted in text format on disk.
- J. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in setpoint that represents a change of actuator position of at least 25 percent of its full range. The sampling rate of the trend shall be from one second to three minutes depending on the speed of the loop. The trend data shall show for each sample the setpoint, actuator position, and the controlled variable values. Any loop that yields unreasonably under or over damped control values shall require further tuning by the contractor.
- K. The control systems will not be accepted as meeting the requirements of Completion until all tests described in this section have been performed to the satisfaction of both the Engineer and Owner and all required documentation has been submitted and successfully reviewed. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the Completion requirements if stated as such in writing by the Owner's representative. Such tests shall then be performed as part of the warranty.
- L. After the system has operated properly for 90 days following startup of the final component of the heating and air conditioning systems, an as-built copy of the software shall be transmitted to the Owner for permanent record purposes. Any software upgrading or enhancements to improve the system operation or as required for proper operation of the system during the first year of operation is the responsibility of this Subcontractor. Any changes to the software shall be immediately transmitted to the Owner, and shall be installed at the job site by the Controls Contractor.

### 3.11 CONTROL EXECUTION - GENERAL

- A. This Contractor shall provide all required control interface relays, including control contactors for single-phase pumps and fans (1/2 hp or less) and any isolation relays required for interface to three-phase magnetic starter control circuits. All power wiring to single-phase motors and three-phase starters by Division 16; all control function (interlock) wiring by the Controls Contractor.
- B. This Contractor shall be responsible for providing control power to all his controllers and devices requiring control power including installation of any required breakers, unless such wiring is shown on the Division 16 drawings.
- C. Accessibility: Install all control devices in readily accessible locations as defined by Chapter 1, Article 100, Part A of the NEC.
- D. Hand-Off-Auto switches at the MCC shall energize equipment in both the 'hand' and 'auto' mode (when auto is commanded on for auto mode). Safeties shall protect equipment in the hand and auto modes. Where fans are interlocked with damper end switches, the hand and auto positions shall open the dampers and the damper end switch shall energize the fan.

### END OF SECTION 15905

#### **SECTION 17010**

#### INSTRUMENTATION AND CONTROL SYSTEMS

### PART 1 - GENERAL

#### 1.01 SUMMARY

#### A. Scope:

- 1. GENERAL: This section specifies general requirements applicable to process instrumentation systems consisting of process sensors, monitoring and control devices, and accessories required to provide a complete and fully functional monitoring and control system.
- 2. RESPONSIBILITY: The Contractor shall provide, configure, calibrate, test, and commission all Mechanical and Electrical components of the instrumentation, control, communications, and network systems supplied unless specifically noted otherwise (UNO). The Contractor shall place the completed systems in operation, and making final adjustments to instruments as required during plant start-up. The Contractor shall provide the services of instrument technicians for testing and adjustment activities.
- Programming of PLC/SCADA systems, including the PLC Ladder Logic, HMI, network, and communications systems programming, will be performed by others, and is *excluded* from the contractor's scope of work.
- 4. Programming of vendor supplied equipment is excluded from the contractor's scope of work.
- RELATED REQUIREMENTS: Division 17 is an extension of, and includes all of the requirements of Division 16, Electrical. All work performed under Division 17 shall also comply with the applicable sections of Division 16 as well as the general provisions of Divisions 0 & 1.
- B. Contract Requirements:
  - 1. General Conditions, Supplementary Conditions, and Division 1 apply to Work in this section.

## C. Definitions:

- 1. General: The definitions of terminology used in these specifications shall be defined in ISA Standard S51.1, unless otherwise specified.
- 2. APPROVED EQUAL: Items that are accepted and approved by the owner, the owners designated project representative, or the engineer as being functionally equivalent for the application and acceptable substitutes for items specified in the contract documents.
- 3. Contractor: The general contractor is responsible for overall project construction. The party with whom the contract is executed.
- CSI: Control System Integrator. An organization engaged in the business of detail design, component purchase, assembly, and implementing process control and industrial electronic systems. Data Sheets: Data sheets as used in this specification shall refer to ISA S20.
- 5. Galvanic Isolation: Pertaining to an electrical node having no direct current path to another electrical node. As used in this specification, galvanic isolation refers to a device with electrical inputs and/or outputs which are galvanically isolated from ground, the device case, the process fluid, and any separate power supply terminals, but such

inputs and/or outputs are capable of being externally grounded without affecting the characteristics of the devices or providing path for circulation of ground currents.

- 6. HMI: Human Machine Interface.
- Integrated Circuit: A number of circuit elements inseparably associated on or within a continuous body to perform the function of a circuit.
- 8. NA: Not Applicable
- 9. Panel: An instrument support system which may be either a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Panels may provide mechanical protection, electrical isolation, and protection from dust, dirt, and chemical contaminants which may be present in the atmosphere. "Panel" shall be understood to include consoles, cabinets, and racks.
- 10. OIT: Touch screen Operator Interface Terminal. Used for HMI as specified.
- PROJECT: In reference to a person the term project shall be used to refer to the owner or representatives of the owner designated by the owner. Synonymous with PROJECT REPRESENTATIVE.
- 12. PACKAGED SYSTEM: Integrated equipment systems that are specified in other divisions and sections of the specifications. These systems include process and mechanical equipment as well as electrical and controls equipment that conforms to the requirements of Division 16 and 17. These systems may include skid mounted and loose items. Some items provided with the equipment may require installation and connection by others. Some related items identified as "supplied by others" may not be supplied with the system but may nonetheless be required for some of the functions of the system.
- 13. SCADA: Supervisory Control and Data Acquisition.
- 14. Signal Types: The following types of signals are used in systems specified in this division.
  - a. Low Level Analog: A signal that has a full output level of 100 millivolts or less. This group includes thermocouples and resistance temperature detectors.
  - b. Digital Code: Coded information such as that derived from the output of an analog to digital converter or the coded output from a digital computer or other digital transmission terminal. This type includes those cases where direct line driving is utilized and not those cases where the signal is modulated.
  - c. Pulse Frequency: Counting pulses such as those emitted from speed transmitters.
  - d. High Level Analog: Signals with full output level greater than 100 millivolts but less than 30 volts, including 4-20 mA transmission.
  - e. Modulated Signals: Signals emanating from modems or low level audio signals. Normal signal level is plus 4 dBm to minus 22 dBm. Frequency range is 300 to 10,000 hertz.
  - f. Discrete Events: Dry contact closures monitored by solid-state equipment. If the conductors connecting to dry contacts enter enclosures containing power or control circuits and cannot be isolated from such circuits in accordance with NEC Article 725, this signal shall be treated as low voltage control.
  - g. Low Voltage Control: Contact closures monitored by relays, or control circuits operating at less than 30 volts and 250 milliamperes.

- h. High Level Audio Signals: Audio signals exceeding plus 4 dBm, including loud speaker circuits.
- Radio Frequency Signals: Continuous wave, alternating current signals with fundamental frequency greater than 10 kilohertz.
- j. 120 VAC control: Contact closures monitored by relays, or control circuits operating at 120 volts AC.
- 15. Solid State: Circuitry or components of a type which convey electrons by means of solid material such as silicon or crystals, or which work on magnetic principles such as ferrite cores. Vacuum tubes, gas tubes, slide wires, stepping motors, or other devices are not acceptable substitutes for solid-state components or circuitry.
- 16. Two-wire Transmitter: A transducer which derives operating power supply from the signal transmission circuit and therefore requires no separate power supply connections. As used in this specification, two-wire transmitter refers to a transmitter which produces a 4 to 20-milliampere, current-regulated signal in a series circuit with a 24-volt direct current driving potential and a maximum circuit resistance of 600 ohms.
- 17. UNO: Unless specifically Noted Otherwise. All general requirements statements shall apply as stated except where specific exceptions are stated, in which case the general requirement shall be modified by the stated exception.
- D. REFERENCE SECTIONS: Requirements of the sections listed below apply to and are related to the work of this Section. Other Sections, not referenced below, may also apply and be related to the proper performance of this work. The Contractor is responsible to perform all the work required by the Contract.
  - 1. Division 01: All Sections, as applicable
  - 2. Section 16010: General Electrical Requirements
  - 3. Section 16123: Control-Voltage Electrical Power Cables
  - 4. Section 16130: Raceways and Boxes
  - 5. Division 17: Instrumentation and Control, all included sections

#### 1.02 QUALITY ASSURANCE

- A. REFERENCED STANDARDS: The latest edition of the documents listed below are included in the Contract where referenced. The most stringent collective interpretation of the requirements shall govern where conflict or overlap exists between any of these documents and the Contract Documents.
  - 1. American National Standards Institute (ANSI)
  - 2. Institute of Electrical and Electronic Engineers (IEEE)
  - 3. Underwriters' Laboratories (UL)
  - 4. The Instrumentation, Systems, and Automation Society (ISA)
  - API RP550: Manual on Installation of Refinery Instruments and Control Systems, Part I – Process Instrumentation and Control Sections 1 Through 13
  - 6. API RP 551: Process Measurement Instrumentation
  - 7. API RP 552: Transmission Systems First Edition

- 8. ANSI/ISA S5.4: Instrument Loop Diagrams
- 9. ISA S20: Specification Forms for Process Measurement and Control Instrumentation, Primary Elements, and Control Valves
- 10. ANSI/ISA S5.1: Instrumentation symbols and Identification
- 11. ANSI/ISA S51.1: Process Instrumentation Terminology
- 12. ISA S5.3: Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer systems
- ISA RP12.2.02: Recommendations for the Preparation. Content, and Organization of Intrinsic Safety Control Drawings
- 14. NFPA 70 National Electric Code (NEC), Title 24, Part 3, California Electrical Code (CEC)
- 15. NFPA 79 Electrical Standards for Industrial Machinery
- 16. NFPA 820Fire Protection in Wastewater Treatment and Collection Facilities
- 17. IBC 1632 International Building Code
- 18. UL 508 Industrial Control Equipment
- B. Listing:
  - 1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
  - 2. Equipment shall be listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
  - 3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer's place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

## 1.03 SUBMITTALS

- A. GENERAL: Submit information per Division 1.
- B. MEDIA: All submittals shall be provided in hard copy (paper) in accordance with Division 1 and electronic format. Electronic format shall be PDF format on CD that is compatible with Microsoft Widows / Adobe Reader. One CD shall be provided for each hard copy required per Division 1.
- C. ORGANIZATION AND FORMAT: Submittal organization shall be the same as the specifications. Provide submittals bound with section coversheets and tabbed dividers with specification section numbers for submittal organization. Bill of materials, cut sheets, shop drawings, schematics, panel layouts, schedules, etc., shall be cross-referenced, indexed, or otherwise related by unique identifier for each item. The project may reject improperly organized or notated submittals. Provide .pdf file page numbers in table of contents as well as bookmark links to section coversheets in pdf file.

- D. REVIEWS AND RE SUBMITTALS: Suppliers shall provide re-submittals which include responses to all submittal review comments separately and at a level of detail commensurate with each comment. Supplier responses shall indicate how the supplier resolved the issue pertaining to each review comment. Responses that only indicate that the review comment was noted, will be looked into, etc., are not satisfactory. Re-submittals which do not comply with this requirement may be rejected and returned without review. Contractor shall be allowed no extensions of any kind to any part of their contract due to the rejection of non compliant submittals. Submittal review comments not addressed by the contractor in re submittals shall continue to apply whether restated or not in subsequent reviews until adequately addressed by the contractor to the satisfaction of the reviewing and approving authority.
- E. PRODUCT DATA: Submit catalog cut sheets for all products. Identify all cut sheets by unique bill of material item number, index, or key. Notate catalog cuts to indicate only those items, models, options, or series of equipment to be furnished. Cross out or otherwise obliterate all extraneous materials and information. Clearly identify all configuration options for the equipment to be furnished.
- F. BILL OF MATERIALS: Submit bill of materials including all items, products, and assemblies supplied. Documents shall be updated following submittal review, factory test, and commissioning. Updates shall be provided to the Project Representative in a timely manner. Bill of materials shall include the following information:
  - 1. Item number, index, or key relating to submitted cut sheets, drawings, schedules, etc.
  - 2. Item manufacturer's name, model, and part numbers. Supplier unique part numbers are not acceptable.
  - 3. Description
  - 4. Quantity supplied
  - 5. Supplier contact information
- G. NOTATED SPECIFICATIONS: Submit copies of all Division 17 specification sections with each paragraph notated to indicate compliance. A check mark shall indicate complete compliance. Explanations shall be provided for all non-compliant items in accordance with Division 1.
- H. NOTATED P&ID DRAWINGS: Submit copies of all project Process and Instrumentation drawings with each drawing element notated to indicate compliance. A check mark shall indicate complete compliance. Explanations and markups shall be provided for all noncompliant items and in accordance with Division 1
- L NOTATED ELECTRICAL AND INSTRUMENTATION DRAWINGS: In the case of deviations from the contract documents, particularly related to the impact of the configuration of submitted packaged equipment supplied to the project, submit marked up copies of applicable Electrical and Instrumentation contract drawings notated to identify and explain all proposed deviations from the contract documents. Items not notated on the submitted marked up copies shall be assumed to be 100% compliant with the bid documents. This requirement applies to electrical one lines, MCCs, MCC control schematics, panel schedules, and control schematics. This requirement does not apply to plan drawings and conduit schedule which shall be marked up to reflect the as constructed project configuration and submitted as record drawings.
- J. SEISMIC: Submit Seismic design information. Include a list of equipment weighing 200 pounds or more.

- K. O&M: Submit operation and maintenance information as specified in any Division 17 specification section. O&M manuals shall include product data for all materials and items supplied in compliance with the submittal requirements of this section.
- L. DIV 17: Submit information as required by all Division 17 specification sections.
- M. CSI: The CSI will be engaged under separate contract with the Owner. Contractor shall not be responsible for work carried out by the CSI.
- N. DRAWINGS: Submit all drawings described in this and other Division 17 sections including elementary, loop, schematic, fabrication, installation, field wiring, panel layout and assembly, etc., drawings. Drawings shall be updated following submittal review, factory test, and commissioning. Updates shall be provided to the Project Representative in a timely manner. Cross reference drawing elements with BOM and catalog cut sheet unique references. Drawings shall use project tag formats and numbers. Unique and separate drawings shall be provided for each item supplied including but not limited to all panels and all MCC units. Typical drawings that apply to multiple panels or multiple MCC motor control units are not acceptable. Individual I/O schematics diagrams are to be provided for each VO slot based on the typicals in the design and the PLC I/O List. Individual motor starter schematics are to be provided for each starter unit including FVNR, VFD and breaker units as well as spare or space units.
- O. PACKAGED EQUIPMENT: All packaged equipment suppliers shall provide submittals in compliance with Division 17. This shall include packaged equipment purchased under the contract as well as any pre purchased packaged equipment assigned to the contractor.
- P. COMPONENT DRAWINGS: Dimensional, installation, and wiring diagrams and drawings for all supplied components.
- Q. TESTING AND CALIBRATION: Test plans, calibration forms, test forms, test results, and test reports required by any Division 17 specification section. Per Section 17804.
- R. SPARE PARTS: Spare parts lists

#### 1.94 SERVICE REQUIREMENTS

- A. ENVIRONMENTAL CONDITIONS: All equipment shall be suitable for operation in the following ambient conditions. Modify equipment if necessary as required to function in the specified environment.
  - 1. Atmospheric contaminants:

Hydrogen sulfide	0.1 mg/L
Chlorine	0.01 mg/L
Ammonia	0.5 mg/L
Dust	50.0 ug/m3

2. Electromagnetic radiation:

3. Control Rooms:

Temperature	60 to 95 degrees F
Humidity	20 to 80 percent

4. Outdoor Field Locations:

Temperature	-10 to 120 degrees F
Humidity	10 to 100 percent
## 1.05 DESCRIPTION OF SYSTEM

## A. General:

- 1. SYSTEM SCOPE: The instrumentation and control system shall include the instruments, control devices, programmable controllers, input and output devices, sensors, interfacing devices, communications devices, cabinets, enclosures, and other components, as required to implement the functional requirements of the Contract.
- 2. DESIGN AND ASSEMBLY: The instrumentation and control system shall be designed by the CSI to be an integrated system composed completely of components that are specifically designed and intended to be used for and in conjunction with the control and operation of motor-driven pumps and process equipment. The control system shall be designed and assembled by the CSI to provide:
  - a. Control of motor driven pumps, equipment, and processes
  - b. Monitoring of operation of motor driven pumps, equipment, and processes
  - c. Indication of operating status of motor driven pumps, equipment, and processes
  - d. The capabilities indicated and implied by Contract documents.
  - e. Reliable communications with the plant SCADA system.
  - 3. Contractor shall be responsible for proper function of the electrical and mechanical components of the instrumentation and control system, as outlined in the Functional Specification, Section 17810. Electrical and mechanical functionality specifically excludes all PLC/HMI programmed functions of the instrumentation and control system, and includes all electrical and mechanical functionality of:
    - a. Control Panel electronics and devices,
    - b. Field instruments and devices
    - c. Local control stations used for Auto/Manual control of PCTF systems and devices
    - d. Electrical and network wiring
    - e. Vendor supplied systems and devices, excluding the programming of those systems and devices. The programmed functions of vendor supplied systems shall be the responsibility of the CSI, who will be engaged by the Owner under separate contract.
  - 4. Contractor shall work with the CSI, and shall inform the CSI of deficiencies in the CSI-designed instrumentation and control system. Contractor and shall recommend solutions to the CSI so that the electrical and mechanical functional requirements of the system can be achieved. Authority for resolution of deficiencies in the electrical and mechanical control system design shall ultimately reside with the CSI.
- 5. CUSTOM PARTS: System components shall be commercial, off-the-shelf (COS) components. Custom designed or manufactured components shall require Project Representatives approval.
- B. Functional Requirements:
  - 1. BID DOCUMENTS: As defined in Division 17 specifications and the contract drawings.
  - 2. MANUAL FUNCTIONS: The system shall readily enable manual operation of any and all equipment functions. Manual equipment operation shall not be reliant on any programmable electronic devices or equipment.

- 3. FAULT TOLERANCE: The system shall be immune to single point failures to the maximum extent practical.
- 4. LOCATION OF FUNCTIONS: The system shall include manual, automatic, programmed, and hardwired functions. The devices that provide these functions shall be located at field mounted control stations, packaged system local control panels, motor control equipment, process area control panels, and plant SCADA equipment.
- C. Preselected Equipment:
  - FUNCTIONAL REQUIREMENTS: Preselected equipment purchased outside of the contract by RFP shall be governed by the RFP and equipment procurement contract. The components, configuration, functions, and features of preselected systems and equipment shall be as negotiated during the selection process and as approved by the project upon vendor selection. The selected vendors will prepare and submit system drawings and documents as required by the RFP which shall include but not be limited to the following:
    - a. Process and Instrumentation drawings and detailed control strategy for the system.
    - b. Detailed control panel shop drawings, loop drawings, communications drawings, field wiring drawings, etc.
    - System layout plan drawings and elevations showing the location of all Division 16 and 17 components
    - d. A list of all Division 16 and 17 items supplied by the vendor that require installation or connection by the contractor.
    - e. A list of items required by the system that are scheduled to be provided by others.
    - f. The preselected system shall be assigned to the contractor for installation and mechanical and electrical integration during the execution of the contractor's contract. The system supplier shall provide a full, detailed, and complete submittal concurrent with the contract submittal phase.
    - g. The integration of preselected system programming with the PCTF PLC/SCADA system shall be assigned to the CSI.
- D. Hierarchical Monitoring And Control System Architecture:
  - 1. Plant systems have been designed to include operator interfaces for all system functions. All systems have been designed to be manually operable via discrete devices and via programmed Human Machine Interface devices. Systems have been designed to be monitored and controlled in a hierarchical manner. Basic functions have been designed to be provided at field stations, local panels, and MCC's by discrete panel switches, indicator lights, and displays. The overall plant wide SCADA system has been designed to provide monitoring and control of all systems and equipment at the plant. All programmable devices and systems have been designed to, and shall communicate over a TCP/IP plant Ethernet network. The CSI, the Contractor, and packaged equipment suppliers shall ensure that all components of supplied plant systems fully and seamlessly integrate into this system architecture.

## 1.96 CONTRACTOR AND SUBCONTRACTOR SCOPES OF WORK

## A. GC Responsibility:

- 1. All programmed functions of the PLC/SCADA instrumentation and industrial electronic shall be provided under the supervision of a single Control System Integrator, contracted directly by Owner, who is regularly engaged in the design, configuration, and installation of similar systems of equal or greater scope and complexity. The Control System Integrator shall NOT be enjoined by the Contractor as a Subcontractor. Programming of the PLC and the SCADA system will be performed by others, but the associated hardware will be supplied by Contractor. Contractor shall be responsible for ensuring operability of all equipment in the instrument and control system including network systems, field equipment, panels, work stations, server racks, control panels, and instruments. Programmed functionality of all equipment in the instrument and control system shall be the responsibility of the CSI. The Contractor shall work with CSI, equipment vendors, and any third party PLC/SCADA programmer to test, commission and start up the automated and programmed functions of the plant.
- 2. ITEMIZED RESPONSIBILITIES: The Contractor shall be responsible for the following equipment and services:
  - a. Detailed Design of Control Panels: The drawings depict the functional and operational requirements of the control system and are at times diagrammatic. The Contractor shall provide detailed, scaled design of all components on and in control panels and determine specific physical, thermal, and electrical requirements.
  - Detailed Design of Control Circuitry: The drawings depict the functional and b. operational requirements of the control system and are at times diagrammatic. The Contractor shall be responsible for the final selection of all control system components, except for components specified as "no equal", and all detailed circuit design and component interconnection required to meet the general and functional requirements indicated in or implied by the Drawings and Specifications. Where components are specified as "no equal", the Contractor shall provide all detailed design, including specification of miscellaneous or interfacing components required to integrate the specified component into the Contractor's control system design. It is the responsibility of the Contractor to ensure that all devices selected, and the proposed interconnection of those devices, perform as intended to provide a complete and operable system meeting the requirements of the anticipated environment and area classifications. The Contractor shall define all requirements for all interfacing components and shall supply all appurtenances, accessories, and all such devices which may be required for proper functioning and interfacing of components as part of the control system. An example of such appurtenances would be interposing relays or analog isolators. All such aforementioned necessary ancillary components not specifically indicated in the Contract Documents shall be considered incidental to the contract and shall be required just as if they had been specifically indicated.
  - c. INTERCONNECTING WIRING: The design of all interconnecting wiring of control equipment, including remote control panels, packaged equipment panels, mechanical equipment with control components, etc. Provide PLC I/O schematics for each PLC slot and Motor Starter schematics for each starter unit in the MCCs showing all the external and internal wiring.

- d. MOTOR CONTROL CENTERS: Supplying the Motor Control Equipment and/or Motor Control Centers (MCCs) in accordance with Division 16.
- e. EQUIPMENT TESTING: Testing of the Motor Control Equipment in the CSI's shop. Testing of control panels in the Contractor's shop under simulated operating conditions. Per Section 17894.
- f. INTEGRATION TESTING: Integration testing of all system and related components simultaneously in the Contractor's facility. This testing shall include all panels, instruments, process switches, test fixtures, MCCs, motor controllers, available equipment packages, communications and networking equipment, SCADA system hardware, PLC system hardware, etc. Per Section 17804
- g. CALIBRATION: Calibration of all field instruments UNO. Per Section 17804.
- COMMUNICATIONS AND NETWORKS: Set up, configure, test, and verify all communications equipment, channels, and networks including new and reused telephone circuits.
- i. STARTUP AND TESTING: System start up, commissioning, electrical and mechanical testing, and functional testing of systems that are not programmed following installation. Per Section 17804. Contractor shall provide electrical and mechanical support to the CSI during the CSI functional testing of systems that are programmed.
- J. INSTRUMENTS: Provide all instruments specified unless specifically noted otherwise. Some instruments shall be provided by packaged equipment vendors. The Contractor shall not be responsible for program integration of vendor provided instruments and equipment.
- k. CONFIGURATION Configure all supplied devices, and equipment unless specifically noted otherwise. All computers are to be configured for application programming by others. Configuration and programming of devices and equipment supplied as a part of packaged systems shall be provided by the vendor of each packaged system. Per Section 17802
- EQUIPMENT SUBMITTAL REVIEW: Review all equipment and packaged system submittals which include Division 17 items. Notify the CSI of any and all needed modifications to submitted equipment, package system scope of services or supply, or CSI programming required to accommodate and integrate submitted equipment into the Contractor's work. Specifically note how submittals which include variances from the contract documents will impact CSI provided programs if accepted by the contractor.
- B. Intent Of Drawings And Specifications:
  - 1. GENERAL: Due to the fact that the contract documents cannot dictate the use of specific brands or models of components and equipment unless there is a compelling reason to do so, the control system drawings are intended to primarily convey detailed functional and operational requirements of the control system rather than specific component selection, assembly, and interconnection information. The substantial interconnection information provided in the Contract Drawings is general in nature and is provided for the purpose of indicating the general scope of work and the aforementioned functional and operational requirements, and shall not be construed to represent detailed shop drawings or parts thereof.

- 2. ANCILLARY COMPONENTS REQUIRED: Components not explicitly indicated in the Contract Documents but none-the-less implied, required for the environment or area classification indicated, or required for the proper functioning of the system as indicated shall be considered required just as though they had been explicitly indicated. The aforementioned components shall be considered incidental to the Contract and shall not constitute a basis for claim by the Bidder for additional compensation or time allowed to complete the Work.
- CONFLICTS IN DOCUMENTS: In any case of conflicting statements or requirements in the contract drawings and specifications, the most demanding statement or combination of statements shall govern. All stated requirements shall be met or exceeded.
- C. Control System Integrator's Responsibilities:
  - SOLE RESPONSIBILITY: In accordance with A and B above, the Control System Integrator (CSI) shall be solely and completely responsible for the detailed design, and commissioning of the programmed functions of the control system with the exception of control equipment provided as a part of packaged equipment systems or otherwise noted as exceptions.
  - DESIGN AND PERFORMANCE: The control system hardware and assemblies shall be designed by the Contractor to provide the control capabilities and functions indicated in and implied by the drawings and these specifications and to provide trouble-free operation with a minimum of maintenance.
  - 3. COORDINATION AND INTEGRATION: The CSI shall be directly responsible for the coordination and integration of the control system with motor controls, packaged equipment controls, and other related equipment. The CSI shall be responsible to obtain submittal information on equipment specified or provided by the Contractor or other suppliers or disciplines and to programmatically integrate all the equipment into the control system to form a complete working system as outlined by the Contract Documents.
  - 4. PROACTIVE COMMUNICATION: The CSI shall communicate directly with the Contractor, manufacturer(s) and supplier(s) of all related equipment to determine all details of the equipment that may influence or affect the programmed functions of the control system. The CSI shall determine all requirements for and shall cause integration of the control system into a unified operating system. All correspondence shall include Carbon Copying (cc:) the General Contractor.
  - 5. ITEMIZED RESPONSIBILITIES: The CSI shall be responsible for the following equipment and services:
    - a. INTEGRATION TESTING: Integration testing of all programmed systems and related components simultaneously in the CSI's facility. This testing shall include all panels, instruments, process switches, test fixtures, MCCs, motor controllers, available equipment packages, communications and networking equipment, SCADA system software (UNO), PLC system software (UNO), etc. Per Section 17804.
    - b. COORDINATION WITH CONTRACTOR: The CSI shall supply the Contractor with all necessary detailed written instructions for installation of all control components and sensing devices as required for proper system operation.

- c. CALIBRATION: PLC/SCADA system calibration of all field instruments UNO. Per Section 17804.
- d. COMMUNICATIONS AND NETWORKS: Set up, configure, test, and verify of all programmed communications equipment, channels, and networks including new and reused telephone circuits.
- e. STARTUP AND TESTING: System start up, commissioning, and functional testing of all programmed systems following installation. Per Section 17804.
- f. INSTRUMENTS: The CSI shall integrate vendor provided instruments and equipment into the PLC/SCADA system.
- g. CONFIGURATION Configure all supplied devices, and equipment into the PLC/SCADA software unless specifically noted otherwise. All computers are to be configured for application programming by the CSI. Configuration and programming of devices and equipment supplied as a part of packaged systems shall be provided by the vendor of each packaged system. Per Section 17802
- h. APPLICATION SOFTWARE DEVELOPMENT: Per Section 17802.
- i. EQUIPMENT SUBMITTAL REVIEW: Review all equipment and packaged system submittals which include Division 17 items. Notify the Contractor of any and all needed modifications to submitted equipment, package system scope of services or supply, or CSI supplied programming required to accommodate and integrate submitted equipment into the Contractor's work. Specifically note how submittals which include variances from the contract documents will impact Contractor provided control panels and MCC's if accepted by the Contractor.
- D. General And Electrical Contractor's Responsibility: The General and Electrical Contractor shall be responsible for the following equipment and services:
  - 1. CSI SUBMITTAL REVIEW: Review of the CSI's submittals and wiring diagrams for coordination with space requirements, raceway requirements of field wiring, etc.
  - EQUIPMENT SUBMITTALS: Supply the CSI with information submittals on all equipment which impacts or connects to the control system, which the Integrator must incorporate into their PLC/SCADA programs and integrate into the project. This includes items such as pumps, motors, packaged control panels, other equipment, valve actuators, etc.
  - 3. INSTALLATION:
    - a. Installation of control panels provided by the Contarctor.
    - b. Installation of Motor Control Equipment (MCC) provided by the Contractor.
    - c. Installation of interconnecting wiring in accordance with the contract documents and the Contractor's wiring diagrams.
    - d. Installation of Instrumentation and Control System components in accordance with the contract documents and instructions of the Contractor.

## 1.97 SHOP DRAWINGS

A. GENERAL: The Contractor, suppliers of packaged control systems, and suppliers of MCCs shall develop all shop drawings required for design, fabrication, assembly, installation, operation, and maintenance of the supplied control system components. Drawings shall be prepared utilizing a computer aided drafting program. CAD shop drawings shall be updated

and provided to the Project Representative prior to factory testing, prior to system installation, and with the O&M manuals. All drawings shall be supplied in hardcopy and electronic file formats per paragraph 1.3.B of this section.

- DIAGRAMS: Submit detailed interconnection diagrams, wiring diagrams, elementary diagrams, communications diagrams, and loop diagrams with all electrical and electronic components clearly identified by project tag number consistent with the contract drawings and schedules. Diagrams for each circuit or element shall be separate and unique. Typical diagrams are not allowed. Diagrams shall carry a date and brief description of the revisions. Diagrams shall carry a uniform and coordinated set of wire and terminal block numbers in compliance with panel work wiring, Section 17110.
- 2. PANEL LAYOUTS: Submit detailed construction drawings for panel layouts and equipment enclosures with dimensions in inches. Show both exterior and interior views.
- 3. WIRE AND TB NUMBERS: Wiring and loop diagrams shall carry a uniform and coordinated set of wire numbers and terminal block numbers in compliance with Division 16 and Section 17110 and with the numbering schemes shown on the contract drawings.
- 4. UNIQUE DRAWINGS: Each control circuit, control loop, control panel layout design, motor control schematic, etc., shall be presented on a unique drawing. Control circuits, loop diagrams, and panel layouts referenced to typical diagrams are not acceptable.
- 5. SYMBOLS: Drawing symbol format shall comply with NFPA 79, ISA 5.1, ISA 5.3 and where appropriate, ISA RP 12.2.02.
- 6. RECORD DRAWINGS: Provide record drawings per Division 1.
- 7. FORMAT: Drawings shall be prepared utilizing a computer based drafting program and shall be formatted as follows:
  - a. SIZE: Hardcopy plots shall be 11-inch by 17-inch (half-size).
  - b. TEXT: Minimum Text size: 0.125 inch for 22 x 34 inch drawings, 0.063 inch for 11 x 17 inch drawings.
  - c. BORDERS: Drawings shall have borders and title blocks identifying the Contract, facility, system, revisions to the drawing, and type of drawing.
  - d. REVISIONS: Each release of a drawing shall carry a revision number, date, and a brief description of the changes. All changes associated with a given release shall be indicated on the drawing by a revision flag. Changes on the latest revision shall be indicated by clouding.
  - e. CAD: Drafting software shall be AntoCAD 2008 or latter. Bind all x-refs.
- 8. FIELD EQUIPMENT TERMINALS: All schematics, diagrams, and drawings showing connections to field equipment shall provide correct terminal block numbers for the connections at the field equipment. This includes packaged system control panels, MCCs, stand-alone motor controls, valve actuators, instruments, switches, etc. The contractor, subcontractors, and suppliers shall coordinate as needed to accomplish this.
- B. ELEMENTARY AND LOOP DIAGRAMS: Provide elementary diagrams for all discrete loops. Loop diagrams shall be prepared in compliance with ISA S5.4 and shall be provided for all analog loops. Elementary diagrams and loop diagrams shall show circuits and devices of a system. These diagrams shall be arranged to emphasize device elements and their

functions as an aid to understanding the operation of a system and maintaining or troubleshooting that system.

- 1. Provide complete elementary diagrams for equipment control.
- 2. Comply with NFPA 79.
- 3. Show wire numbers, color codes, signal polarities, and terminal block numbers. Tables for wire numbers, signal polarity, and terminal block numbers are not acceptable.
- C. SCHEMATIC DIAGRAMS: Provide schematic drawings showing all control panel components, the interconnection of all control panel components, all field devices, and the connection of all field devices to control panels. Schematic diagrams shall also show all communications components, their interconnection, and their interface with other control panel components. Provide wire and terminal block numbers in compliance with panel work wiring, Section 17110.
- D. PANEL FABRICATION AND ARRANGEMENTS DRAWINGS: Provide arrangement drawings of all panel front and internal-mounted instruments, switches, devices, and equipment indicated. All panel mounting details shall be shown. Outer dimensions of all panels shall be included on the drawing. Deviations from approved arrangements shall require Project Representatives approval prior to installation. Arrangement drawings shall be drawn to scale using standard Architectural or Engineering scales.
- E. Record Drawings:
  - 1. Also referred to as as-built drawings.
  - 2. SHOP DRAWINGS: All submitted drawings shall be updated over the course of the construction project to reflect the installations and equipment as-built. A full set of record drawings shall be provided to the Project Representative upon completion of the project and shall be included in the O&M manuals. Record drawing requirements shall be the same as submittal drawing requirements.
  - 3. CONTRACT DRAWINGS: The contractor shall maintain a set of record plan and P&ID markup drawings on site during construction. The contractor shall mark up the record drawing set to indicate any and all deviations of the installed systems from the contract documents. The marked-up drawings shall be provided to the project representative at project close out.
- F. Wiring Diagrams:
  - 1. Panels: comply with NFPA79.
  - 2. Show components of a control panel in an arrangement similar to the actual layout of the panel.
  - 3. Show internal wiring between devices within the panel.
  - Show all terminal blocks whether used for internal or field wiring. Those used for field wiring shall be clearly identified as such.
  - 5. Wiring diagrams shall indicate insulation color code, signal polarities, wire numbers, and terminal block numbers.
- G. Interconnection Diagrams:
  - 1. Submit complete interconnection diagrams for field wiring.
  - 2. Show each panel and field devices.

- 3. Show wire numbers, cable numbers, panel numbers, and field device tag numbers.
- 4. Comply with NFPA79.
- H. Certifications:
  - 1. Temperature: Provide test data certified by the manufacturer to demonstrate that field electronic devices are suitable for the specified ambient temperatures.
  - 2. Corrosion: Provide test data showing design features of the electronic equipment provided to protect against damage by the specified atmospheric contaminants and specific evidence that similarly protected electronic equipment has operated in similar environments for a period of not less than five years without failure due to corrosion.

## 1.08 SEISMIC DESIGN

- A. Procedure and submittals: per Section 16010.
- B. Structures and equipment shall be braced to prevent damage from specified forces.
- C. Equipment shall not be required to function properly during periods of seismic disturbance, but shall be capable of manual restart without repair or modification following a disturbance.

## 1.10 PRECEDENCE OF REQUIREMENTS

The Contractor, Sub Contractors and equipment suppliers shall comply with all requirements specified in the contract documents, individually and in combination. In the case of redundant, overlapping, or conflicting requirements, the most stringent and demanding interpretation of the requirements statements collectively shall govern unless specifically clarified by the project. The Contractor and equipment suppliers shall request needed clarification of requirements during bid, otherwise the project's interpretation shall govern. The System Supplier shall diligently scrutinize all parts of all bid documents prior to bid.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

PRODUCTS: All products provided by the Contractor shall be manufactured to comply with the listing requirements identified in Part 1 and other requirements as indicated in the Contract. System components shall be commercial, off-the-shelf components to the maximum extent possible. Custom designed or manufactured components shall require Project Representative's approval.

## 2.02 MATERIALS

- A. GENERAL: Material shall be new, free from defects, and of the quality specified. All equipment and materials utilized in the system shall be the products of Manufacturers with at least five (5) years of experience in the manufacture of similar equipment. Similar items in the system shall be the products of the same Manufacturer. All equipment shall be of industrial grade and of standard construction, shall be capable of long, reliable, trouble-free service, and shall be specifically intended for control and monitoring of operation of motor-driven pumps and process equipment. All equipment shall be of modular design to facilitate interchangeability of parts and to assure ease of servicing.
- B. ELECTRONIC COMPONENTS: Unless otherwise specified, electronic equipment shall be of solid-state construction. Components of standard electronic assemblies shall not be replaced with components of different characteristics in order to meet the performance requirements of the specification. Parts shall be as shown in the instruction manuals and shall be replaceable

with standard commercial components of the same description without degrading the performance of the completed assembly.

## 2.03 INSTRUMENTS

Application requirements are specified in the individual specification sections, and/or on the drawings. The major instruments required to implement the process instrumentation and control systems are identified on the P&IDs. Instruments identified shall be supplied with the exception of those identified within the limit of supply of vendor equipment. Instruments within vendor boundaries will be supplied by equipment suppliers. All instrument functions specified on the P&IDs and contract drawings have Division 17 specification references and shall be provided by the Contractor. Any additional instruments or devices required to complete the instrument loops because of unique characteristics of the particular equipment selected by the Contractor (such as isolation J/Is) shall be provided. Such additional instruments shall be considered incidental to the contract and shall be provided and included in the original contract price even when not specified in the contract drawings.

## 2.04 SPARE PARTS

- A. In addition to spare parts mentioned elsewhere in Division 16 & 17 specification sections, the Contractor shall supply the following spare parts for use by the District:
  - 1. Qty 1 Relay of each type used or 10%, whichever is the greater amount
  - 2. Qty 10 lamps of each type used or 100%, whichever is the greater amount.
  - 3. Qty 200% spare fuses, two spare fuses for each type of fuse supplied minimum

## PART 3 - EXECUTION

#### 3.01 DESIGN AND ASSEMBLY

- A. GENERAL: With the exception of any packaged equipment control systems, the supplied control systems shall be designed by the Contractor per paragraph 1.06. The supplied control system shall be completely assembled in the shop of and by the Contractor. All components and equipment shall be prewired to the maximum extent possible.
- B. ELECTRICAL AND MECHANICAL INTEGRATION: The Contractor shall determine all requirements for and shall cause electrical, mechanical and network integration of the supplied control systems, MCCs, and any supplied packaged equipment control systems into a complete and unified system. The Contractor shall be responsible for the electrical and mechanical coordination and integration of the supplied control system with motor controls and other related equipment.
- C. PROGRAM INTEGRATION: The CSI shall determine all requirements for and shall cause programmed integration of the supplied control systems, MCCs, and any supplied packaged equipment control systems into a complete and unified system. The CSI shall be responsible for the programmable coordination and integration of the supplied control system with motor controls and other related equipment.
- D. REVIEW OF SUBMITTALS: The Contractor shall be directly responsible to obtain submittal information on related equipment supplied by others and to integrate this information as required with the overall control system to form a complete working package.
- E. COORDINATION: The Contractor shall communicate directly with the Manufacturer(s) and Suppliet(s) of all related equipment to determine all details of the equipment that may influence or affect the supplied control system components. The Contractor shall work with the CSI to make any and all adjustments or revisious required to integrate the submitted

equipment into the job at no additional expense to the owner and with no extension of the schedule.

## 3.02 DELIVERY, STORAGE, AND HANDLING

- A. Shipping:
  - 1. Anchor, brace, and protect equipment during shipping handling.
  - 2. No internal wiring shall be disconnected for transportation.
- B. Delivery Inspection: Notify the Project Representative and provide access for inspection upon arrival of any material or equipment to be incorporated into the work. Remove protective covers when required.
- C<sub>e</sub> Supplied Control Panels:
  - 1. Completely wired and tested in the factory prior to being shipped to the job site.
  - 2. Shipped as a single unit to job site after testing is complete.
  - 3. No internal wiring shall be disconnected for transportation.

## 3.03 INSTALLATION

- A. General:
  - 1. INSTALLATION BY CONTRACTOR: The control system and associated instruments and connections shall be installed by the contractor.
  - INSTALLATION INSTRUCTIONS: The control system shall be installed in accordance with the installation drawings and instructions provided by the CSI, packaged system suppliers, and other equipment suppliers.
  - SUPERVISION: The Contractor's instrumentation and controls project engineer shall supervise and coordinate all activities related to the installation of Division 17 requirements.
  - 4. EXPERTISE OF INSTALLER: Installation shall be performed by the workers who are skilled and experienced in the installation of electrical instrumentation and control systems. Installation shall include all elements and components of the control systems and all conduit and interconnecting wiring between all elements, components, sensors, valve operators, etc.
  - LOCATION: Equipment shall be located so that it is readily accessible for operation and maintenance.
  - 6. INSTRUMENT TECHNICIAN: The Contractor shall provide the services of skilled instrument technicians for testing, calibration, and adjustment activities per 17804.
- B. Signal Connection And Transmission:
  - 1. Unless otherwise specified, analog signal transmission between electric or electronic instruments not located within a common panel shall be 4 to 20 milliamperes and shall have a loop compliance of at least 500 ohms.
  - 2. Two-wire loop transmitters shall operate at 24 VDC.
  - Unless otherwise shown, milliampere signals from the field shall be converted to 1 to 5 VDC signals at the field terminal block of each panel. Conversion error shall not exceed 0.1%. All instruments within a panel shall be parallel wired with 1-5 VDC signals.

- 4. Loops shall be grounded at the field terminal block by bonding to the instrument panel signal ground bus. Separate grounded conductors shall be provided for each loop. Daisy chaining of grounded conductors from one loop to another is not allowed.
- 5. Provide isolating amplifiers for field equipment possessing a grounded input or output, or having a common mode voltage other than system ground.
- 6. Convert high frequency (greater than 50 Hz) pulse rate signals from field transmitters to analog 1-5 VDC signals at the panel.
- Convert platinum resistance temperature detector (RTD) outputs to 4-20 milliampere signals at the RTD, or where shown on the Drawings. The temperature milliampere signal may be brought from the field to the panel and converted to a 1-5 Volt DC signal.
- 8. All other transmission systems, such as impulse duration, low frequency pulse rate, and voltage regulated, will not be permitted. When transmitters with non-standard outputs are specified, their output shall be converted to 4 to 20 milliamperes at the field instrument.
- 9. Equipment located in classified areas shall be explosion-proof or intrinsically safe. Provide intrinsic safety barriers approved by UL, CSA, or FM.
- C. TAGGING: All field devices shall be labeled with tag number indicated in the bid documents or consistent with project tagging conventions when not shown in the bid documents. Comply with project naming and numbering conventions. Tag shall be 10ga, 316 stainless steel with stamped letters and numbers attached to device with 12ga, 316 stainless steel wire.
- D. Field Equipment:
  - 1. INSTALLATION: Equipment shall be provided as specified on the drawings such that ports and adjustments are accessible for in-place testing and calibration. Where possible, equipment shall be located between 48 inches and 60 inches above the floor or a permanent work platform. Instrumentation equipment shall be mounted for unobstructed access, but mounting shall not obstruct walkways. Equipment shall be mounted where shock or vibration will not impair its operation. Support systems shall not be attached to handrails, process piping or mechanical equipment except for measuring elements and valve positioners. Instruments and cabinets supported directly by concrete or concrete block walls shall be spaced out not less than 5/8 inch by framing channel between instrument and wall.
  - 2. SUPPORT SYSTEMS: Steel used for support of equipment shall be hot-dip galvanized after fabrication. Support systems including panels shall be designed in accordance with the applicable building code and seismic zone and shall prevent deformation greater than 1/8 inch under the attached equipment load and an external load of 200 pounds in any direction.
- E. Electrical Power Connections:
  - 1. DIVISION 16: Electric power wiring and equipment shall be in compliance with Division 16.
  - 2. DISCONNECT SWITCHES: Power disconnect switches shall be provided within sight of equipment and shall be labeled to indicate opened and closed positions and specific equipment served. "Within sight of" is defined as having a clear unobstructed view from the equipment served and within 50 feet of the equipment served. Disconnect switches shall be mounted between 36 inches and 72 inches above the floor or permanent work platform. Where equipment location is such that the above requirements cannot be met

by a single disconnect switch, two switches, one at the equipment and one at the work platform, shall be provided.

- 3. SURGE ARRESTORS: Each disconnect switch serving equipment located outdoors shall be provided with a surge arrestor, General Electric 9L15CCB001, or equal. The surge arrestor shall be bonded to the plant ground grid with a No. 8 AWG bare copper conductor.
- 4. CONTROL PANELS: All control panels shall be provided with a main power disconnect equipped with auxiliary contacts as required to disconnect all power sources to the panel or shall be labeled to indicate the multiple power sources not disconnected by the main disconnect. Field wiring for all power sources not disconnected by the main disconnect shall land on fused disconnect type terminal blocks.

## 3.04 TESTS AND INSPECTIONS:

Per Section 17804.

#### 3.05 CALIBRATION, START-UP, AND COMMISSIONING:

Per Section 17804.

#### 3.06 SYSTEM MAINTENANCE AND WARRANTY

- A. Contractor SOLELY RESPONSIBLE: The Contractor shall be solely and completely responsible for all electrical and mechanical maintenance of control systems they supply from time of installation to the date of substantial completion of all work under the contract. The Contractor shall correct all deficiencies and defects and make any and all repairs, replacements, modifications, and adjustments as malfunctions or failures occur. The contractor shall perform all such work required or considered to be required by the owner to properly maintain the system.
- B. DEFECTS AND REPAIRS: The Contractor shall make any and all repairs, replacements, modifications, and adjustments required to eliminate any and all defects in design, materials, and workmanship which are discovered within the one year guarantee period. The Contractor shall begin all repairs, replacements, modifications and adjustments within twenty-four (24) hours of notification by telephone by the owner and shall complete such repairs, replacements, modifications and adjustments within forty-eight (48) hours of notification.
- C. ACCEPTANCE OF WORK: The Contractor shall anticipate that the Owner may delay acceptance of all work under the contract if, in the judgment of the Owner, malfunctions or failures in operation of the supplied control system repeatedly occur after start-up to an unacceptable extent. The Contractor shall not be entitled to an extension of time or to any claim for damages because of hindrances, delays, or complications caused by or resulting from delay by the owner in accepting the work because of malfunctions or failures in operation of the supplied control system.
- D. PACKAGED SYSTEMS: Packaged system suppliers shall provide warranty support meeting the above stated requirements for their supplied systems.

#### 3.07 OPERATION AND MAINTENANCE DATA

- A. O&M MANUALS: The Contractor shall prepare and assemble six (6) sets of electrical and mechanical operation and maintenance (O&M) manuals in accordance with the project general requirements and Paragraph 1.3 of this section. These manuals shall be submitted two weeks prior to training. O&M manuals shall include, but not be limited to, the following:
  - 1. Trouble-shooting procedures.
  - 2. Calibration procedures.
  - 3. Testing procedures.
  - 4. Component replacement procedures.
  - 5. Preventative maintenance procedures.
  - 6. Listing of recommended spare parts.
  - 7. Listing of recommended maintenance tools and equipment.
  - 8. Catalog data for all equipment and devices supplied, organized per submittal requirements.
  - 9. Configuration and setup manuals for all devices supplied including VFDs, instruments, etc.
  - 10. Communication channel test forms.
  - Calibration and test forms for all field switches, instruments, PLC IO, VFD IO, etc, per Section 17804.
  - 12. Configuration files for all configurable electronic devices and equipment supplied for this project.
  - 13. System user's manual covering all functions supplied by the contractor for this project as described below.
- B. RECORD DOCUMENTS: All contract P&ID drawings and control strategy specification sections and all submittal drawings shall be revised to reflect as-built conditions at the end of the project. Record drawings and documents shall be submitted in accordance with the project general requirements and Paragraph 1.3 of this section. Record drawings and documents shall be submitted with the O&M manuals. Record drawings and documents shall include the following:
  - 1. Shop drawings per 1.7 of this section.
  - 2. Wiring diagrams of cabinet and enclosure contained assemblies
  - Wiring diagrams of all system connections and interconnections including all loops, field equipment, communications interfaces, networks, etc.
  - 4. All other submitted shop and installation drawings and details not listed
  - 5. Bill of Material
  - 6. Contract P&ID drawings
  - 7. Contract control strategy specification sections

## 3.98 SYSTEM USERS MANUAL

- A. SCOPE: The Contractor shall develop and submit a detailed user manual covering all aspects of the operation and use of the components and systems they supply. The manual shall cover the following
  - 1. OVERVIEW: An overview of the architecture of the control system including control panels, MCC's, field devices, networks, remote access, etc.
  - 2. FUNCTIONS: All hardware/hardwired, manual, automatic, display, control, alarming, networking, etc. features and functions of the systems and components they supply.
  - 3. HARDWIRED ELEMENTS: Descriptions of the meaning and function of all hardwired panel, MCC, and field mounted discrete operator interface monitoring and control devices. Correlate functions to the control strategies.
  - 4. START UP: System start up procedures for electrical and mechanical systems supplied and configured by the contractor for the project.
- B. USED IN TRAINING: The system users manual shall be completed prior to and shall be used for required training. The manual shall be updated to incorporate comments received during training and re submitted for inclusion in the O&M manual. Submit 2 weeks prior to training.
- C. PACKAGED EQUIPMENT: Packaged equipment suppliers shall supply user's manuals per the above requirements for the systems they supply.
- D. PLC/SCADA SYSTEM MANUALS: The PLC/SCADA system OM&M Manuals shall be the responsibility of the CSI. The Contractor shall support the CSI as needed for development of the CSI portion of the OM&M Manuals

## 3.09 TRAINING

- A. GENERAL: The Contractor shall conduct specifically organized training sessions to educate and train the owner's personnel in the maintenance and operation of all aspects and components of the control system they supply. Training on all system components shall include, but not be limited to, the following subjects:
  - 1. All electrical and mechanical O&M manual items
  - 2. All system users' manual items
- B. TRAINING SESSIONS: The Contractor shall provide a minimum of 16 hours of on-site instruction to the owner's employees after start-up and commissioning of the system. The owner shall be allowed to video tape all or any part of the training sessions. The Contractor shall prepare and assemble specific instruction materials for each training session and shall supply such materials to the Project Representative at least two (2) weeks prior to the time of the training. The O&M manuals and the system users' manual shall be complete and shall be used in the training sessions.
- C. PLC/SCADA SYSTEM TRAINING: PLC/SCADA System Training shall be conducted by the CSI. The Contractor shall not be responsible for PLC/SCADA system training
- D. VFD TRAINING: Training shall cover details of operation of VFD's from the HIM (Human Interface Module). Training shall provide detailed instructions on the modification of VFD operating parameters typically requiring adjustment by operators. The contractor shall develop and provide "cheat sheets" which provide step by step instructions required to accomplish the following:
  - 1. Copy VFD configuration to HIM

- 2. Copy HIM configuration to VFD
- 3. Switch between auto and manual modes
- 4. Manually adjust speed
- 5. Adjust minimum and maximum speed limits
- 6. Adjust acceleration and deceleration ramp times
- 7. Access parameters and fault codes

## END OF SECTION 17010

## SECTION 17221

## FIELD INSTRUMENTS GENERAL

## PART 1 - GENERAL

## 1.01 SUMMARY

- A. This Section specifies general requirements for field instruments. This section applies to instrumentation elements that quantitatively convert sensed process energy into a form/signal compatible with process measurement, control, and display devices and accessories.
- B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.
  - 1. Section 17010: Instrumentation and Control Systems.
- C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.
- D. Not all products listed are required for all applications. Submit only products required for the application.

## 1.92 QUALITY ASSURANCE

- A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below. In case of conflict between the requirements of this Section and those of the listed documents, the more demanding requirements shall govern.
  - 1. ANSI B16,5 Pipe Flanges and Flanged Fittings
  - 2. API RP550 Manual on Installation of Refinery Instruments and Control Systems, Part 1- Process Instrumentation and Control
  - 3. ASTM A276 Stainless Steel Bars and Shapes
  - 4. NEMA 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)
- B. Listing:
  - 1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
  - 2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
  - 3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer's place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

## 1.03 SUBMITTALS

Per Section 17010-1.3.

FIELD INSTRUMENTS GENERAL 17221-1

TETRA TECH: 8/12

## PART 2 - PRODUCTS

## 2.01 TRANSMITTERS:

- A. Unless otherwise specified, transmitters shall comply with the following requirements:
  - 1. Two-wire type with operating power derived from the signal transmission circuit, unless otherwise specified.
  - 2. Output shall be 4 to 20 mA, current regulated DC.
  - 3. Load variations within the range of 0 to 500 ohms with the power supply at 24 VDC
  - 4. Output shall be galvanically isolated.
  - 5. Time constant of transmitters used for flow or pressure measurement, including level transmitters used for flow measurement, shall be adjustable from 0.0 to 5.0 seconds.
  - 6. Output shall increase with increasing measurement.
  - 7. Unless otherwise specified, enclosures shall be rated NEMA 250, Type 4X.
  - 8. Provide with surge protectors when located outdoors:
  - 9. Where two-wire transmitter is located in a classified area, use intrinsic safety barrier as specified below.
  - 10. DIGITAL COMMUNICATIONS: Provide HART or approved equal digital communications where available. Only one instrument communications protocol will be allowed.
  - 11. Provide programming device and software utilities for communications capable devices.
  - 12. Acceptable manufacturer:
    - a. Rosemount
    - b. Endress + Hauser
    - c. Yokogawa
    - d. Krohne
    - e. Approved equal

## 2.02 OUTPUT INDICATORS

- A. Provide with any transmitter that does not include an integral indicator.
- B. Output indicator shall be a loop powered current-to-digital display indicator.
- C. Input current shall be 4-20 mA and display shall be a 3 1/2 active digit liquid crystal display with black numerals at least 0.35 inches high.
- D. Display scalable with decimal point to read process engineering units.
- E. Enclosed in a hockey puck type housing with glass window, classified as appropriate for the area in which the output indicator is installed.
- F. A diode shall be provided to maintain loop continuity in case of indicator failure or removal.
- G. Accuracy shall be +/- 0.1 percent of reading.
- H. Indicators, whether integral or separate, shall be calibrated in process units.
- I. The units shall be engraved on the indicator scale plate.
- J. The installed orientation of the output indicator shall enable operators to easily read the display from the operating floor.

FIELD INSTRUMENTS GENERAL

- 1. Action Instruments models V561/V565
- 2. Precision Digital models 697/698
- 3. Moore Industries models PSD/SPD
- 4. Approved equal

## 2.03 DETAILED INSTRUMENT REQUIREMENTS

Detailed requirements for specific instruments are specified in other Division 17 specification sections.

## 2.04 INTRINSIC SAFETY BARRIERS

- A. Shall be two-wire, active, isolating, loop powered type.
- B. Mounting: DIN Rail
- C. Acceptable Manufacturer:
  - 1. Measurement Technology LTD, type MT3042
  - 2. Stahl 9005/01-252/100/00
  - 3. Approved equal

## 2.95 SIGNAL CURRENT ISOLATOR (FIELD MOUNTED)

- A. Provides Galvanic isolation of milliampere transmission signals from transmitters with inadequately isolated output circuits. House in a NEMA 250, type 4X/7 conduit body. Derive its operating power from the signal input circuit.
- B. Input and output signals shall be 4 to 20 mA and error shall not exceed 0.1 percent of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.
- C. Acceptable Manufacturer:
  - 1. Action Instruments model T700
  - 2. Moore Industries model SCX
  - 3. Acromag model 150i
  - 4. Approved equal

## PART 3 - EXECUTION

## 3.01 INSTALLATION

- A. Installation requirements per Section 17010.
- B. Electrical Connections: Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of two feet.
- C. Tagging: All field instruments shall be labeled with function and instrument number, i.e. (FIT-901-01/A-STREAM INFFLUENT FLOW METER). Tag shall be 10ga 316 stainless steel with stamped letters and numbers attached to device with 12ga 316 stainless steel wire.

## 3.02 TESTING

Testing requirements per Section 17010.

## END OF SECTION 17221

TETRA TECH: 8/12

## SECTION 17231

#### ANALYTICAL INSTRUMENTS

## PART 1 - GENERAL

#### 1.01 SUMMARY

- A. This Section specifies requirements for analytical instruments. This section applies to instrumentation elements that quantitatively convert sensed process parameters into a form/signal compatible with process measurement, control, and display devices and accessories.
- B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.
  - 1. Section 17221: Field Instruments General
- C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.
- D. Not all products listed are required for all applications. Submit only products required for the application.

#### 1.02 QUALITY ASSURANCE

Per Section 17221 Field Instruments General.

## 1.03 SUBMITTALS

Per Section 17010-1.03.

#### PART 2 - PRODUCTS

## 2.01 DETAILED INSTRUMENT REQUIREMENTS

- A. Requirements for instruments are specified in this section and ou INSTRUSPEC sheets in Part 3.
- B. Installation and application requirements are specified in Division 17 Sections, and/or on the contract Drawings.

## PART 3 - EXECUTION

## 3.01 INSTRUSPEC SHEETS

A. INSTRUSPEC sheets provide detailed requirements for the instruments listed below.

 INSTRUSPEC Symbol	Instrument Description	Instrument Function
AIT3	Process Fluid Analyzer	PH Measurement
A0'4	Process Fluid Analyzer	Suspended Solids Measurement

Instrument Identification:	AIT3 (AE/AIT pH)
Instrument Function:	pH measurement
Instrument Description:	pH Analyzer
Power Supply:	120 VAC

Signal	Innut:	NA
Signar	mpac.	7.4%

(2)	4-20	ma	DC.	HA	$\mathbf{RT}$

Signal Output:

Probe, submersible, 1" MNTP

Product Requirements:

General:

- Measurement of pH by the sensor is accomplished by immersing a glass or metal electrode and a reference electrode into a process solution. Measured pH is related to the logarithm of hydrogen ion activity in the solution. This instrument also provides temperature compensation.
- 2. Cable: Provide signal cable between the primary element and transmitter by the system manufacturer, 15 feet maximum length.

#### Sensor:

- 1. Sensing electrode: Flat glass suitable for abrasive solutions.
- 2. Preamplifier: Remote, sensor to transmitter distance 15 feet maximum.
- 3. Temperature range: 0 to 110 degrees C.
- 4. Pressure range: 0 to 100 psig.
- 5. Temperature Compensation: Integral pt100 sensor. Automatic compensation from 32 to 185 degrees F.
- 6. Materials of construction: Tefzel, glass, cerawic, Viton.
- 7. Submersion depth: 2.5 inches to 23 feet.
- 8. Maximum pressure at operating temperature: 100 psi at 65 degrees F, 50 psi at 85 degrees F.
- 9. Power supply: Transmitter.
- 10. Provide Integral cable with quick disconnect
- 11. Approval: FM.
- 12 Rating: Class 1, Division 1, Groups A, B, C, and D; Class 2, Division 1, Groups E and G, hazardous locations, explosion proof, intrinsically safe.
- Installation in hazardous location shall be intrinsically safe, FM certified, and listed per NEC 504. Provide all required certificates, control drawings, and intrinsic safety calculations, etc. as required by the application.

#### Transmitter:

- 1. Enclosure: NEMA 4X, IP65, NEMA 7B, suitable for area classifications.
- 2. Display: 2 line 7 segment LCD display.
- Configuration: Provide software configuration tools and all required connection accessories.
- 4. Ambient temperature range: -4 to 149 degrees F.
- 5. Relative humidity: 0 to 95% non condensing.
- 6. Temperature resolution: .1 degree C.
- 7. RFI/EMI: EN-61326, CE.
- 8. Measurement range: 0 to 14 pH.
- 9. Preamplifier: Integral, sensor to transmitter distance 15 feet maximum.

- 10 Temperature compensation: Pt 100 RTD located in the sensor, 5 to 270 degrees F.
- 11. Accuracy: ±1 mV @ 25degrees C±0.01 pH.
- 12. Repeatability: ±1 mV @ 25degrees C ± 0.01 pH.
- 13. Stability: .025% per year at 25 degrees C.
- 14. Internal diagnostics.
- 15. Mounting option: Field, as indicated on the drawings.
- 16. Approval: FM.
- 17. Rating: Class 1, Division 1, Groups A, B, C, and D; Class 2, Division 1, Groups E and G, hazardous locations, explosion proof, intrinsically safe.
- 18. Installation in hazardous location shall be intrinsically safe, FM certified, and listed per NEC 504. Provide all required certificates, control drawings, and intrinsic safety calculations, etc, as required by the application.

- 1. Endress + Hauser Liquiline CM442 with sensor CPF81D
- 2. Hach GLI sc200 digital multi-channel with PEEK PDP digital sensor
- 3. Approved equal.

#### Installation:

- 1. Per the manufacturer's instructions and recommendations
- 2. As shown on the Drawings.
- 3. Sensor Mounting:
  - a. In-line via ball valve assembly.
  - b. In a sample line via twist-lock flow chambers.
  - c. In-line via twist-lock bushings or tees.
  - d. In-situ via electrode protection sleeve.
  - e. As indicated on the drawings.

#### Calibration:

- 1. Calibrate per Sections 17900 Schedules.
- 2. Calibrate per the manufacturer's instructions.

Instrument Identification:	AIT4 (TSS)
Instrument Function:	Suspended Solids measurement
Instrument Description:	TSS Analyzer
Power Supply:	120 VAC
Signal Input:	NA
Signal Output:	(2) 4-20 ma DC, HART
Process Connection:	Sensor, 1 ½ "NPT 316 SS isolation valve assembly and male nipple to attach to 1 ½ NPT boss or saddle in pipe supplied by contractor.

ANALYTICAL INSTRUMENTS 17231-3

#### Product Requirements:

General:

1. Continuous on-line measurement of suspended solids in the range of 0-50,000 ppm or mg/l range. Normal operating range 0-500 ppm for this application.

#### Sensor:

- 1. Single NIR (Near Infra-Red) light beam generated by a light emitting diode (LED) and received by a silicon detector.
- 2. Sensor housing is to be made of 316SS with glass lenses.
- 3. Designed for 90 psig (6 bar) working pressure and supplied with integral builtin mechanical stop.
- 4. Integral SS flushing nozzle with check valve.
- 5. Mount in a 1.5" npt female connection on pipe.
- 6. Gap between lenses is to be to be 15mm.
- 7. Sensor to be supplied with 33' (10 m) of shielded 4-conductor cable with polyurethane jacket and metallic M12-connector with o-ring scal.
- 8. Measuring range of 30-30,000 ppm
- 9. Sensor to have integral SS flushing nozzle.
- Transmitter (Control Box):
  - 1. Enclosure: NEMA 4X, IP65
  - 2. Support two sensors.
  - 3. Two independent linearized 4-20 mA, max 500 ohms galvanically isolated, output signals (12 bit resolution) proportional to suspended solids concentrations.
  - 4. Illuminated graphical ICD display.
  - 5. Graphical display to show solids concentrations in ppm, mg/l or % solids and 0-100% of mA output
  - 6. Graphical display to show calibration points and current suspended solids concentration.
  - 7. dampening feature or integration time, which can be set from 1 to 999 seconds.
  - 8. Built-in heater to maintain proper temperature down to -20 F outside temperature.
  - 9. Approval: FM.
  - 10. Flushing solenoid valve prewired in control box
  - 11. Output to be held constant during flushing cycle.
  - 12. Flushing liquid to be 40-60psig filtered reuse water a compressed air.
  - 13. Control box to have (4) 3/16" holes for mounting.
  - 14. Sun-light resistant components, exposed to direct sunlight.
  - 15. All programming and settings performed exterior to the control box by using a self-instructing menu, controlled by three touch pad keys.

ANALYTICAL INSTRUMENTS 17231-4

TETRA TECH: 8/12

- 1. Ceriic ITX-IL
- 2. Approved equal.

# Installation:

- 1. Per the manufacturer's instructions and recommendations
- 2. As shown on the Drawings.
- 3. Sensor Mounting:
  - a. In-line via ball valve assembly.
  - b. As indicated on the drawings.

## Calibration:

- 1. Calibrate per Sections 17900 Schedules.
- 2. Calibrate per the manufacturer's instructions.

## END OF SECTION 17231

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## **SECTION 17241**

## FLOW TRANSMITTERS

## PART 1 - GENERAL

#### 1.01 SUMMARY

- A. This Section specifies requirements for flow transmitters. This section applies to instrumentation elements that quantitatively convert sensed process flow energy into a form/signal compatible with process measurement, control, and display devices and accessories.
- B. Related Sections: The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.
  - 1. Section 17221: Field Instruments General
- C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.
- D. Not all products listed are required for all applications. Submit only products required for the application.

#### 1.02 QUALITY ASSURANCE

Per 17221 Field Instruments General.

## 1.03 SUBMITTALS

Per 17010-1.3.

## PART 2 - PRODUCTS

## 2.01 DETAILED INSTRUMENT REQUIREMENTS

- A. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in Part 3.
- B. Installation and application requirements are specified in this section, section 17901, and/or on the contract Drawings.

## PART 3 - EXECUTION

## 3.01 INSTRUSPEC SHEETS

A. The following INSTRUSPEC sheets provide detailed requirements for the listed instruments.

INSTRUSPEC Symbol	Instrument Description	Instrument Function
FM1	Magnetic flow meter	Flow measurement
FM2	Propeller flow meter	Flow measurement

FM1
Flow measurement
Magnetic flow metering system
120 VAC (transmitter)
Induced Voltage
4-20 mA DC, Digital
Flange, ANSI B16.5 Class 150, raised face

Product Requirements:

General:

- 1. Magnetic flow meter shall be provided as a system consisting of a flow tube and remotely mounted converter/transmitter complete with all necessary interconnecting cables for the flow tube to transmitter separation shown.
- 2. System shall be suitable for measuring water and sludge flow.
- 3. Provide grounding rings for both upstream and downstream connections with the process piping.
- 4. Provide mechanical protection for the flow tube flanges and liner during installation or removal of the flow tube.
- 5. Provide pipe reducer and expander where pipe run size is different from specified flow tube size.
- 6. The reducer and expander shall be uniformly diverging and converging swages with a total reducing angle not exceeding 8 degrees.
- 7. Flow Tube and transmitter shall be the products of the same manufacturer recommended for use together by the manufacturer.

#### Flow Tube:

- 1. The inside diameter of the flow tube is shown the Process Mechanical drawings of the bid documents.
- 2. Flow tube features: measuring tube material 304 stainless steel; liner material will be Polyurethane for sizes less than 2", and hard rubber for sizes 2" and larger.
- 3. Pulsed DC field excitation with automatic zero point correction.
- 4. Field coil insulation class E.
- 5. Field replaceable electrodes replaceable when flow tube is under operating pressure.
- 6. Electrode material 316 Ti stainless steel
- 7. Housing: NEMA 4X.
- 8. Grounding ring material 316 Ti stainless steel

## Transmitter:

- 1. Signal converter/transmitter shall be suitable for an adjustable full-scale flow within the limits of from 1 to 30 feet per second.
- Signal converter / transmitter shall be remotely mounted from flow tube and microprocessor based. Provide cable for 25 foot remote connection. Actual distance to be verified with site and customer requirements.
- 3. Bi-directional flow and totalization measurement.
- 4. Integral high-contrast LCD display, integral control panel.
- 5. Accuracy of 0.3% of Rate.
- 6. Signal output 4-20 mA DC, galvanically isolated and internally powered 500 ohm driving capability.
- 7. Low-flow cutoff: adjustable from 1% to 3% of range
- 8. Terminals and signal converter modules plug in and replaceable without recalibration or resetting and upgradeable to comply with future communication standards.
- 9. Adjustable dampening: 0.2 to 256 seconds
- 10 Power 120 VAC.
- 11. Enclosure: NEMA 4X wall mount.
- 12. Flow rate calibration per Section 17900 Schedules.

#### Acceptable manufacturer:

- 1. Endress + Hauser Promag 50W
- 2. Approved equals.

## Installation:

- 1. Install in accordance with manufacturer's instructions, API RP550, and the specified functional requirements.
- 2. Install ground rings upstream and downstream of the flow tube.
- 3. Install the transmitter on the wall near to but remotely from the flow tube.
- 4. Provide signal cable between the primary element and transmitter by the system manufacturer.
- 5. Provide a sufficient length of cable for installation of a continuous run between the primary element and the remotely mounted transmitter.

#### Calibration:

- 1. Range shall be per Section 17900 Schedules.
- 2. Instrument shall be calibrated and certified at the factory by the manufacturer.

## END OF SECTION 17241

## SECTION 17242

## LEVEL TRANSMITTERS

## PART 1 - GENERAL

## 1.01 SUMMARY

- A. This Section specifies requirements for level transmitters. This section applies to instrumentation elements that quantitatively convert sensed process level into a form/signal compatible with process measurement, control, and display devices and accessories.
- B. The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.
  - 1. Section 17221: Field Instruments General
- C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.
- D. Not all products listed are required for all applications. Submit only products required for the application.

## 1.02 QUALITY ASSURANCE

Per Section 17221 Field Instruments General.

## 1.03 SUBMITTALS

Per Section 17010-1.3.

## PART 2 - PRODUCTS

## 2.01 DETAILED INSTRUMENT REQUIREMENTS

- A. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in Part 3.
- B. Installation and application requirements are specified in this section, section 17901, and/or on the contract Drawings.

## PART 3 - EXECUTION

## 3.01 INSTRUSPEC SHEETS

A. The following INSTRUSPEC sheets provide detailed requirements for the listed instruments.

INSTRUSPEC Symbol	Instrument Description	Instrument Function
LT1	Submersible Gage Pressure Transmitter	
LT2	Head Monitoring Level Transmitter	Level Measurement
LT3	Level (Differential Pressure) Transmitter	Level Measurement
LT4	Ultrasonic Lovel Transmitter	Level Measurement
LT5	Sludge Blanket Meter	Level Measurement

Instrument Identification: LT1

Instrument Function:	Level Measurement
Instrument Description:	Submersible Vented Gage Pressure Transmitter
Power Supply:	120VAC to remote transmitter
Signal Input:	Process
Signal Output:	4-20 ma DC, digital, HART
Process Connection:	NA

Product Requirements:

Sensor/Cable:

- 1. Pressure sensor shall be temperature compensated silicone peizo-resistive bridge type, shock and vibration-resistant design.
- 2. Wetted parts shall be ASTM A276, type 316 stainless steel minimum unless otherwise specified
- 3. Fluid fill shall be inert Silicone oil/grease, unless otherwise specified.
- 4. Process connection: Teflon-coated flush elastomeric diaphragm with retaining ring, 1" diameter minimum.
- 5. Sensor to be 2-wire device that will connect to remote transmitter
- 6. Cable: 2-wire pluse case ground. Polyurethaue jacket, length 25 feet to remote transmitter (actual length to be determined in the field with customer approval and may be less)
- 7. Agency approval: UL or FM listed
- 3. Rating: NEMA 250, Type 6 (IP68), waterproof form immersion to 3x range.
- 9. Atmospheric reference: vent tube molded into cable

#### Transmitter:

- 1. Transmitter to be remote NEMA 250, Type 4X enclosure
- 2. 120VAC power supply
- 3. 4-20mA input channel
- 4. Terminal Enclosure: provides vent tube with weatherproof, bug-proof atmospheric vent.
- 5. Location: unclassified area
- 6. Indicator: Transmitters shall be provided with an output indicator which shall be 90-degree movement, or LCD.
- 7. Indicator scale shall be calibrated in process units with tic marks for milliampere input.
- 8. Accuracy shall be within 2 percent of span.
- 9. Range shall be selected so calibration point is between 20% and 80% of the scaleable range.

- 1. GE/Druck model PTX
- 2. Approved equal

#### Instrument Identification: LT2

Instrument Function:	Level Measurement
Instrument Description:	Head Monitoring Level Transmitter
Power Supply:	24 VDC
Signal Input:	Process
Signal Output:	4-20 ma DC, digital, HART
Process Connection:	NA

Product Requirements:

- 1. Transmitter shall be "smart" with capacitance or resonant-wire type.
- 2. Wetted parts shall be ASTM A276, type 316 stainless steel minimum unless otherwise specified
- 3. Span shall be adjustable over a 6:1 or greater range.
- 4. Over range capacity without affecting calibration shall be not less than 200 percent of maximum specified range.
- 5. Volumetric displacement shall not exceed 0.01 cubic inches over the specified span.
- 6. Fill fluid unless otherwise specified shall be silicone oil.
- 7. Adjustable dampening shall be provided.
- 8. External zero and span adjustment shall be provided.
- 9. Accuracy shall be 0.25 percent of span or better for spans greater than 5 inches water column, and 0.5 percent of span or better for spans less than or equal to 5 inches water column.
- 10. Monitor shall be 150 lb., 3 inch flange.
- 11. Indicator: Transmitters shall be provided with an output indicator which shall be 90-degree movement, or LCD, 2-1/2 inch milliammeter enclosed in a NEMA 7/9 meter case.
- Indicator scale shall be calibrated in process units with tic marks for milliampere input.
- 13. A diode shall be provided to maintain loop continuity in case of meter movement failure or removal.
- 14. Accuracy shall be within 2 percent of span.
- 15. Range shall be selected so calibration point is between 20% and 80% of the scaleable range.
- 16. Kalrez seal.

- 1. Endress + Hauser Cerabar PMC71
- 2. Approved equal

## Installation:

- 1. Per Section 17010.
- 2. Per the manufacturer's instructions and recommendations.
- 3. Follow the recommendations of API RP550.

#### Calibration:

- 1. Per Section 17901.
- 2. As required by the process.

Instrument Identification:	LT3		
Instrument Function:	Level Measurement		
Instrument Description:	Level (Differential Pressure) Transmitter		
Power Supply:	9-30 VDC		
Signal Input:	NA		
Signal Output:	4-20 ma DC, digital, HART		
Process Connection:	Two 1/2-inch female NPT flange adapters.		

Product Requirements:

- 1. Pressure transmitter shall be capacitance or silicone piezo-resistive bridge type.
- 2. Unless otherwise specified, wetted parts shall be ASTM A276, Type 316 stainless steel.
- 3. Rangeability: 15:1.
- 4. Unless otherwise specified, fill fluid shall be DC 200 Silicone oil.
- 5. Adjustable dampening: 0.5 to 10 seconds.
- 6. External zero adjustment.
- 7. Accuracy shall be +0.1 percent of span.
- 8. Transmitters shall be available in 10° WC to 600 PSIG ranges. Specific ranges shall be designated in Section 17901 Instrument Index.
- 9. Provide differential pressure transmitters with a three-valve manifold per Section 17211 and with four 1/4-inch drain/vent ports, two plugged and two provided with bleed valves.
- 10. Static pressure rating shall be 2,000 psig or greater.
- 11. Smart transmitter sub-carrier compatibility with digital protocol.
- 12. FKM Viton seal.

- 1. Endress + Hauser Deltabar PMD75
- 2. Approved equal

lustallation:

- 1. Per Section 17010.
- 2. Per the manufacturer's instructions and recommendations.
- 3. Follow the recommendations of API RP550.

#### Calibration:

- 1. Per Section 17901.
- 2. Calibrate as required by the process.

#### Instrument Identification: LT4

Instrument Function:	Level measurement
Instrument Description:	Ultrasonic Level Transmitter
Power Supply:	120VAC
Signal Input:	Ultrasonic
Signal Output:	4-20 ma DC, digital, HART
Process Connection:	Non Contact

Product Requirements:

- 1. Beam width shall be 6 degrees or less.
- 2. Rangeability shall be 100:1.
- 3. Accuracy shall be 0.2 percent of calibrated range.
- 4. Provide integral or remote LCD display and configuration module as required by the application.
- 5. Provide available software configuration tools.
- 6. Approvals: Instrument shall bear the CE mark.
- 7. Honsing: Aluminum T12 NEMA 6P IP68, NEMA 4X IP66, with separate terminal compartment.
- 8. Provide integrated temperature sensor for temperature compensation.
- Provide adequate cable for continuous connection to terminating device indicated on the drawings without splices.
- 10. Ambient and process temperature range shall be -40 to 140 degrees F.
- 11. Provide echo suppression function.
- 12. Provide measured value resolution of .08" or better.
- 13. Measuring error shall be less than +/- .16" Or .2% of measuring distance.

#### Acceptable Manufacturers:

1. Endress + Hauser Prosonic FMU90 with sensor FDU.

## 2. Approved Equal

Installation:

- 1. Install in accordance with the manufacturer's instructions.
- 2. Follow the recommendations of API RP550.
- 3. Install as required by the application.
- 4. Install as shown on the drawings.

## Calibration:

- 1. Calibrate per Section 17900 Schedules.
- Coordinate instrument calibration with the Project Representative at the time of purchase and installation.

Instrument Identification:	L'I'S
Instrument Function:	Level measurement of sludge blanket
Instrument Description:	Sludge Blanket Meter
Power Supply:	120VAC
Signal Input:	Near Infrared (NIR) Optical Sensor
Signal Output:	4-20 ma DC, digital
Process Connection:	Travelling, Submersed

Product Requirements:

Sensor:

- 1. Measuring range: 1.5 to 26 feet
- 2. Cable: shielded 4-wire, polyurethane cable, length 36 ft.
- 3. Material: 316 SS
- 4. Location: Submersed
- 5. Lens material: BK7 glass
- 6 Measuring principle: NIR optical sensor
- 7. Sensor and transmitter shall be compatible products manufactured by the same company and recommended by the manufacturer for the application

#### Transmitter:

- 1. Environment:
  - a. Location: Outdoor
  - b. Temperature: -20 to 50 degrees C
- 2. Range: 1 to 26 feet
- 3. Accuracy: .25% of max range or 6 mm, whichever is greater
- 4. Resolution: .1% of program range or 2 mm, whichever is greater
- 5. Programming: LCD display, membrane keypad
- 6. Power supply: 115V/60Hz

- 7. Power consumption: 20VA, 10VA staudby, 70VA with heater
- 8. Analog Outputs: four each 4-20 mA, max loading 750 ohms .1% resolution, isolated
- 9. Relay outputs: minimum 2 form A/ 1 form C, all relays 5A, 250 VAC non inductive
- 10. Flush water supply: 1/2" hose nipple
- 11. Cable: Per manufacturers recommendations
- 12. Approvals: CE, FM, CSA, UL
- 13. Enclosure: NEMA 4

- 1. Cerlic CBX system with 4-channel control box
- 2. Or approved equal

#### Installation:

- 1. Install in accordance with manufacturer's instructions
- 2. Install as required by the application
- 3. Install as shown on the drawings.

#### Calibration:

1. Calibrate per Section 17900 Schedules.

## END OF SECTION 17242

## SECTION 17243

## PRESSURE TRANSMITTERS

## PART 1 - GENERAL

## 1.01 SUMMARY

- A. This Section specifies requirements for pressure transmitters. This section applies to instrumentation elements that quantitatively convert sensed process pressure into a form/signal compatible with process measurement, control, and display devices and accessories.
- B. The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.
  - 1. Section 17221: Field Instruments General
- C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.
- D. Listed instruments: Not all products listed are required for all applications. Submit only products required for the application.

## 1.02 QUALITY ASSURANCE

Per Section 17221 Field Instruments General.

## 1.03 SUBMITTALS

Per Section 17010-1.3.

## PART 2 - PRODUCTS

## 2.01 DETAILED INSTRUMENT REQUIREMENTS

- A. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in Part 3.
- B. Installation and application requirements are specified in this section, Section 17901, and/or on the contract Drawings.

## PART 3 - EXECUTION

#### 3.01 INSTRUSPEC SHEETS

A. The following INSTRUSPEC sheets provide detailed requirements for the listed instruments.

INSTRUSPEC Symbol	Instrument Description	Instrument Function
PDT	Differential pressure transmitter	Pressure measurement
PGT	Gage pressure transmitter	Pressure measurement

Instrument Identification:	PE/PDIT
Instrument Description:	Differential pressure transmitter
Instrument Function:	Differential Pressure (Level) measurement
Power Supply:	9-30 VDC
Signal Input:	N/A
Signal Output:	4-20 mA DC, digital, HART
Process Connection:	Two 1/2-inch female NPT flange adapters.

Product Requirements:

- 1. Pressure transmitter shall be capacitance or silicone piezo-resistive bridge type.
- 2. Unless otherwise specified, wetted parts shall be ASTM A276, Type 316 stainless steel.
- 3. Unless otherwise specified, fill fluid shall be DC 200 Silicone oil.
- 4. Adjustable dampening: 0.5 to 10 seconds.
- 5. Transmitters shall be available in 10" WC to 600 PSIG ranges. Specific ranges shall be designated in Section 17901 Instrument Index.
- 6. Provide differential pressure transmitters with a three-valve manifold per Section 17211 and with four 1/4-inch drain/vent ports, two plugged and two provided with bleed valves.
- 7. Static pressure rating shall be 2,000 psig or greater.
- 8. Smart transmitter sub-carrier compatibility with digital protocol.
- 9. FKM Viton seal

10. Transmitter shall have HistoRom/M-DAT Setup/Diagnotic.

- 11. Span shall be adjustable over a 100:1 or greater range.
- 12. Over range capacity without affecting calibration shall be not less than 200 percent of maximum specified range.
- Volumetric displacement shall not exceed 0.01 cubic inches over the specified span.
- 14. Adjustable dampening shall be provided.
- 15. External zero and span adjustment shall be provided.
- 16. Reference Accuracy shall be 0.075 percent of set span
- 17. Transmitter shall be remotely mounted at a distance of 25 feet (actual distance may be less, to be determined with owner's representative in field)
- 18. Range shall be selected so calibration point is between 20% and 80% of the scaleable range.

#### Acceptable manufacturer:

- 1. Endress + Hauser Deltabar PMD75.
- 2. Approved equal
#### Installation:

- 1. Install in accordance with manufacturer's instructions
- 2. Follow the recommendations of API RP551.
- 3. Provide root valves at all process pressure taps.
- Located pressure measurements as close as practical to the process tap and positioned to permit observation and maintenance from grade or work platform unless otherwise specified.
- 5. Do not support pressure instruments from process piping, unless otherwise specified.

## Calibration:

1. Per Section 17901 Instrument Index.

Instrument Identification:	PE/PIT
Instrument Description:	Gage pressure transmitter *
Instrument Function:	Pressure measurement
Power Sapply:	9-30 VDC
Signal Input:	NA
Signal Output:	4-20 mA DC, digital, HART
Process Connection:	Process connection shall be 316L 1/2 NPT or 1" or 2" flange based upon application requirements

#### Product Requirements:

- 1. Pressure transmitter shall be capacitance type or silicone strain gage type.
- 2. Unless otherwise specified, wetted parts shall be ASTM A276, type 316 stainless steel.
- 3. Rangeability: 15:1 minimum.
- 4. Fill fluid shall be DC 200 Silicone oil, unless otherwise specified ...
- 5. Range: Transmitters shall be available in 0 to 600 PSIG ranges. Specific ranges shall be designated in Section 17901.
- Transmitters with spans less than or equal to 25 psig shall be provided with one 1/2-inch flanged process connection and two 1/4-inch drain/vent ports, one plugged and one provided with bleed valve.
- 7. Reference diaphragm shall be provided with a weatherproof, bug-proof atmospheric vent.
- 8. Transmitters for spans greater than 25 psig shall be similar to the above except shall be designed for gage pressure service, and overpressure rating shall be greater than the lesser of 2,000 psig and 150 percent of maximum range.
- 9. Provide smart transmitter sub-carrier capability compatible with digital protocol.
- 10. Transmitter shall be remotely mounted at a distance of 25 feet (actual distance may be less, to be determined with owner's representative in field)

- 11. Transmitter shall have HistoRom/M-Dat Setup/Diagnotic software.
- 12. Sensor shall be ceramic
- 13. Span shall be adjustable over a 100:1 or greater range.
- 14. Over range capacity without affecting calibration shall be not less than 200 percent of maximum specified range.
- 15. Volumetric displacement shall not exceed 0.01 cubic inches over the specified span.
- 16. Transmitter enclosure shall be Aluminum IP66/67 NEMA 6P
- 17. Adjustable dampening shall be provided.
- 18. External zero and span adjustment shall be provided.
- 19. Accuracy shall be 0.075 percent of span
- 20. Transmitters shall be provided with an output indicator which shall allow for 90-degree movement, or LCD..
- 21. Indicator scale shall be calibrated in PSL

#### Acceptable manufacturer:

- 1. Endress + Hauser Cerabar PMC71
- 2. Approved equal

### Installation:

- 1. Install in accordance with manufacturer's instructions
- 2. Follow the recommendations of API RP550 to the specified requirements.
- 3. Provide root valves at all process pressure taps.
- Provide gage values at the instrument where the instrument is not within sight of the root value or where two or more instruments are connected to a single tap.
- 5. DO NOT connect safety instruments to the same process tap as instruments used for control, indication, or recording.
- Unless otherwise specified, pressure instruments shall be located as close as practical to the process tap and shall be positioned to permit observation and maintenance from grade or a maintenance platform.
- 7. Pressure instruments shall NOT be supported from process piping.

#### Calibration:

1. Per Section 17901 Instrument Index.

#### END OF SECTION 17243

## SECTION 17245

# TEMPERATURE TRANSMITTERS

## PART 1 - GENERAL

## 1.01 SUMMARY

- A. This Section specifies requirements for temperature transmitters. This section applies to instrumentation elements that quantitatively convert sensed process temperature into a form/signal compatible with process measurement, control, and display devices and accessories.
- B. The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.
  - 1. Section 17221: Field Instruments General
- C. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.
- D. Not all products listed are required for all applications. Submit only products required for the application.

## 1.02 QUALITY ASSURANCE

Per Section 17221 Field Instruments General.

## 1.03 SUBMITTALS

Per Section 17010-1.3.

## PART 2 - PRODUCTS

## 2.01 DETAILED INSTRUMENT REQUIREMENTS

- A. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in Part 3.
- B. Installation and application requirements are specified in this section, Section 17901, and/or on the contract Drawings.

#### PART 3 - EXECUTION

#### 3.01 INSTRUSPEC SHEETS

A. The following INSTRUSPEC sheets provide detailed requirements for the listed instruments.

INS	TRUSPEC Symbol	Instrument Description	Instrument Function
	TT	Temperature Transmitter	Temperature measurement

Instrument Identification:	TT
Instrument Function:	Temperature measurement
Instrument Description:	Temperature transmitter
Power Supply:	120VAC, 60 Hz or 24 VDC, 8 VA maximum
Signal Input:	2, 3 or 4-wire RTD 100 Ohm Platinum, or T/C type J, K, E, N, R, S, T or B
Signal Output:	4-20 mA DC, digital
Process Connection:	Thermowell per Section 17211
Product Requirements:	

Sensor:

-1. Provide a sensor in accordance with Section 17901.

## Transmitter:

- 1. Transmitter shall convert the sensor resistance or mV output to a milliampere transmission signal output with an accuracy of  $\pm 0.1$  percent of range or better.
- 2. Input range: As specified in Section 17901.
- 3. Input Sensitivity:
- 4. Input Impedance:
- 5. Accuracy and stability: +0.1% of range or 0.1 degrees C, whichever is greater, for 2 years with RTD sensor and 1 year with T/C sensor.
- 6. Isolation: Input/Ontput/Power 500 VAC minimum
- 7. Transmitter shall provide output power for sensor or Cold Junction compensation for sensor, as required.
- 8. Display: 3-1/2 digit integral LCD display w/ decimal point, minus sign, and degrees Centigrade/Fahrenheit indicator.
- 9. Approvals: FM Explosion proof and/or Intrinsically safe in hazardous areas
- 10. Enclosure:
  - a. NEMA 4X in non hazardous areas
  - b. NEMA 7 in hazardous areas
  - c. Max. Dimensions: 4.7 inch (120 mm) dia. x 5.2 inch (132 mm) Depth
- 11. Environmental:
  - a. Operating Temperature: -20 degrees C to + 70 degrees F
  - b. Humidity: 0 85%, non-condensing
  - c. Altitude: 0 500 meters

# Acceptable Manufacturers:

- 1. Endress + Hauser TH13
- 2. Approved equal

Installation:

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- 1. Install per manufacturer's instructions and recommendations.
- 2. Follow the recommendations of API RP-551.

Calibration:

1. Application, sensor, and calibration requirements per Section 17901.

# END OF SECTION 17245

## SECTION 17251

## PROCESS SWITCHES

# PART 1 - GENERAL

#### 1.01 SUMMARY

- A. This Section specifies requirements for process and non process activated switches.
- B. Performance Benchmarks: Items listed by part number are intended to serve as performance benchmarks. Submit most current model meeting the benchmark performance requirements for items that have been superseded or are otherwise obsolete UNO.
- C. Not all products listed are required for all applications. Submit only products required for the application.

#### 1.92 REFERENCED SECTIONS

- A. The work of the following Sections is related to the work of this Section. Other Sections, not referenced below, may also be related to the proper performance of this work. It is the Contractor's responsibility to perform all the work required by the Contract Documents.
  - 1. Section 17010: Instrumentation and Control Systems.

## 1.03 QUALITY ASSURANCE

- A. Referenced Standards: This Section incorporates by reference the latest revision of the documents listed below. In case of conflict between the requirements of this Section and those of the listed documents, the more demanding requirements shall govern.
  - 1. API RP550 Manual on Installation of Refinery Instruments and Control Systems, Part 1 - Process Instrumentation and Control
  - 2. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
  - 3. NEMA ICS 2 Industrial Control Devices. Controllers and Assemblies
  - 4. NEMA ICS 6 Industrial Control and Systems: Enclosures
- B. Listing
  - 1. All materials and equipment specified herein shall be within the scope of Nationally Recognized Testing Laboratory (NRTL) examination services, be approved by the NRTL for the purpose for which they are used, and shall bear the appropriate listing/label.
  - 2. Equipment listed/labeled by an NRTL acceptable to the local authority having jurisdiction.
  - 3. When a product is not available with a listing/label for the purpose for which it is to serve, the product may be required by the inspection authority to undergo a special inspection at the manufacturer's place of assembly or as a completed assembly in the field. All costs and expenses incurred for such inspections shall be included in the original contract price.

# 1.04 SUBMITTALS

Per Section 17010-1.03.

# PART 2 - PRODUCTS

## 2.01 GENERAL

- A. SWITCHES: Unless otherwise specified, switches shall comply with the following requirements:
  - 1. Contact outputs used for alarm actuation shall be ordinarily closed and shall open to initiate the alarm.
  - 2. Contact outputs used to control equipment shall be ordinarily open and shall close to start the equipment.
  - Contacts monitored by solid-state equipment such as programmable logic controllers or annunciators shall be hermetically sealed and designed for switching currents from 20 to 100 mA at 24 VDC.
  - 4. Contacts monitored by electromagnetic devices such as mechanical relays shall be rated NEMA ICS 2, designation B300.
  - 5. Double barriers shall be provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
  - 6. Switch electrical enclosures shall be rated NEMA 250, Type 4X minimum.
  - 7. Provide suitable intrinsic-safety barriers for contacts in hazardous areas that are monitored by equipment in safe areas.
  - BUSSED INSTRUMENTS: Provide Device Net. Foundation Field Bus, or approved equal for digital communications of process switch signals. Only one digital protocol for process switches communications shall be allowed.
- B. Requirements for instruments are specified in this section and on INSTRUSPEC sheets in Part 3.
- C. Installation and application requirements are specified in this section, section 17901, and/or on the contract Drawings.

## 2.02 INTRINSIC SAFETY BARRIERS AND RELAYS

- A. Intrinsic safety barriers for process switches:
  - 1. Dual input, passive type.
  - 2. Shunt diode barrier construction with non-replaceable fuse and internal current limiting resistor
  - Listings: UL, FM or CSA certified for use in Class I Groups A, B, C. D; Class II Groups E, F, G.
  - 4. Acceptable manufacturers:
    - a. Ronan X57 Series
    - b. Turck MZ-61 Series
    - c. Approved equal
- B. Intrinsic safety relays:
  - 1. Isolates field contacts in classified location from control circuits in non-classified location.

- 2. Input:
  - a. Maximum field contact current/voltage: 10 mA/11 VAC
  - b. Turn-on sensitivity: < 100K Ohms
  - c. Turn-off sensitivity: >1 Megaohm
- 3. Output:
  - a. SPST N.O./N.C. switching action field programmable
  - b. Rating: 1 A resistive at 24 VDC or 120 VAC
- 4. Power: 100 to 130 VAC, 50-60 Hz, 4 VA maximum
- 5. Listings: UL of FM approval for use in Class I Groups A, B, C, D. Class II Groups E, F, G.
- 6. Enclosure: NEMA 1
- 7. Acceptable manufacturers:
  - a. Gems SafePak model 54820
  - b. Stahl IS Isolator Type 9170
  - c. Square-D series 8501 TO or NY2
  - d. Warrick series 17 or 27
  - e. Approved equal

# PART 3 - EXECUTION

## 3.01 INSTALLATION

- A. Installation requirements per Section 17010.
- B. Electrical Connections: Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of two feet.
- C. Tagging: All field instruments shall be labeled with function and instrument number, i.e. (FIT-301/EFFLUENT FLOW METER). Tag shall be 10ga 316 stainless steel with stamped letters and numbers attached to device with 12ga 316 stainless steel wire.

# 3.02 TESTING

Testing requirements per Section 17010.

## 3.03 INSTRUSPEC SHEETS

The following INSTRUSPEC sheets provide detailed requirements for the listed devices.

INSTRUSPEC Symbol	Instrument Description	Instrument Function
FS1	Thermal dispersion flow switch for water, air, nitrogen	Flow threshold detection
FS2	Insertion paddle type flow switch	Flow threshold detection
LS1	Level Switch, float	Level measurement
LS2	Level Switch, stem supported	Multi-level measurement
LS3	Level Switch, conductivity	Multi-level measurement
LS4	Level Switch, Displacer Float	Multi-level measurement
PS	Pressure switch	Pressure measurement
PDSH	Differential Pressure switch, high range	Differential pressure measurement
PDSL1	Differential Pressure switch, low range	Differential pressure measurement
PDSL2	Differential Pressure switch, low range	Differential pressure measurement, EP
TS	Temperature switch	Temperature Monitor (Fluid immersion)
VS	Vibration switch	Equipment vibration monitor
ZSI	Door position switch	Intrusion detection
ZS2	Mechanical equipment position switch	Position Limit detection

# Instrument Type Symbol:

Instrument Description:	Thermal dispersion flow switch.
Instrument Function:	Flow threshold detection for water, air, and nitrogen
Process Connection:	-3/4" or larger MNTP, application dependent.

FS1

Product Requirements:

General:

1. Switch shall be suitable for flow / no flow detection of water, air, and nitrogen gas in process piping.

(1)

Sensor:

- 1. Sensor material shall be 316 stainless steel.
- 2. Operating temperature range shall be -50 to 350 degrees  $F_{\rm ev}$
- 3. Maximum operation pressure shall be 4000 psig.
- 4. Response time: 3 seconds
- 5. Repeatability: +/- 0.5% of range
- 6. Probe length: 1.2", 1.8", custom

Transmitter:

- 1. Housing: UL/CSA rated explosion proof ad needed
- 2. Temperature: -50 to 150 degrees F
- 3. Power Supply: 120 VAC 60Hz 4 watts
- 4. Relay Output: SPDT 3 amps resistive
- 5. Connections: 1" FNPT

Acceptable manufacturer:

- 1. Ameritrol Inc., FX series
- 2. Fluid Components International
- 3. Magnetrol Thermatel
- 4. Approved equal

#### Installation:

- 1. Install according to the manufacturers recommendations.
- 2. Install as indicated on the Drawings.

Calibration:

1. Calibrate per Section 17901.

# Instrument Type Symbol: FS2

# Instrument Description:insertion paddle type flow switchInstrument Punction:Flow threshold detection for waterProcess Connection:Insertion

Product Requirements:

- 1 Flow switches shall be insertion paddle type.
- 2. Provide snap action from C contract closure output.
- 3. Set point shall be adjusted by the insertion length of flow switch paddle.
- 4. Paddle shall be 316 stainless steel.
- 5. Provided with NEMA 4X junction box.

Acceptable manufacturer.

- 1. Gems FS-550
- 2. Approved equal

Installation:

- 1. Install according to the manufacturers recommendations.
- 2. Install as indicated on the Drawings.

Calibration:

1. Calibrate per Section 17901.

Instrument Identification:	LSI
Instrument Function:	Level measurement
Instrument Description:	Float level switch
Power Supply:	N/A
Signal Input:	N/A
Signal Output:	Contacts
Process Connection:	N/A

Product Requirements:

- 1. SPST tilt actuated switch.
- 2. Switch shall not contain mercury.
- 3. High buoyancy, foam filled, durable, corrosion resistant float housing.
- 4. 14-AWG wire type SO cable with PVC outer jacket.
- 5. Tilt switch shall be rated for two amps at 120 VAC minimum.
- 6. Cable length as needed, field verify.
- 7. Contacts: 1 NO or 1 NC

## Acceptable manufacturer.

- 1. US Filter Model 9G-EF
- 2. Anchor Scientific Solo-Float
- 3. Approved equal

## Installation:

- 1. Install per Contract Drawings.
- 2. Install per the manufacturer's instructions.

Calibration:

1. Per Section 17901

Instrument Identification:	LS2
Instrument Function:	Multi-level measurement
Instrument Description:	Stem Mounted Multiple Float Switch
Power Supply:	120VAC
Process:	Waste water
Sigual Input:	NA
Signal Output:	Contacts
Process Connection:	N/A

Product Requirements:

- 1. Switch shall be a SPST.
- 2. Switch shall be UL or FM approved.

- 3. Provide four actuation levels.
- 4. Lead wire length shall be 24".
- 5. Mount and stem material shall be 316 SS.
- 6. Ploat material shall be SS.
- 7. Float diameter shall be Mfr std.
- 8. Float operating temperature limit shall be up to 150°F.
- 9. Float operating maximum pressure shall be 100 PSI.
- 10. Electrical connection junction box shall be NEMA 4 type.

### Acceptable manufacturer:

- 1. GEM8 Model LS700
- 2. Barksdale BLS-800
- 3. Approved equal

Installation:

1. Install per manufacturers recommendations.

2. Per the contract drawings.

Calibration:

1. Per Section 17901.

Instrument Type Symbol:	L83
Instrument Function:	Multi Point level detection.
Instrument Description:	Conductivity seasor.

Product Requirements:

Electrode Holder:

**Process** Connection:

- 1. Assembly capable of holding up to seven 1/4-inch-diameter rod type probes.
- 2. 3-inch male pipe thread attachment to electrode chamber.

3-inch male pipe thread.

- 3. Die-cast epoxy-coated aluminum terminal housing.
- 4. 316 stainless steel body.
- 5. 3/4-inch boss for electrical conduit.

#### Electrodes:

- 1. 1/4-inch 316 stainless steel rod threaded on one end for attachment to electrode holder.
- 2. PVC heat shrunk sheathing.
- 3. Each probe cut to exact length for the sensing elevations as shown on Drawings.

## Electrode Relay Module:

- 1. Power supply: 120 VAC 60Hz
- 2. Solid state plug-in module.
- 3. One form-C SPDT load contact per module.
- 4. Minimum contact rating 8 amp resistive at 120VAC.
- 5. Temperature: -50 to 140 degrees F
- 6. Direct or inverse acting.
- 7. Field adjustable sensitivity.
- 8. Primary voltage 120VAC.
- 9. Secondary circuit: 11VAC RMS, 2.3 milliamps
- 10. NEMA i enclosure.
- 11. UL approved for hazardous location use, intrinsically safe.

#### Acceptable manufacturer:

- 1. Warrick Controls Series 3E probe fitting
- 2. Warrick Controls Series 27 relay module
- 3. Warrick Controls Series 3B or 3H as required by the application
- 4. All components shall be the products of a single manufacturer
- 5. Approved equal

#### installation:

- 1. Install in accordance with manufacturer's instructions.
- 2. As specified on the Drawings.

#### Calibration:

- 1. Set and reset points shall be per Section 17901
- 2. As specified on the Drawings.

Instrument Type Symbol:	1.84
Instrument Function:	Multi-level measurement
Instrument Description:	Level Switch, Displacer Float
Process Connection:	As required

Product Requirements:

- 1. Level switches shall be spring tensioned cable supported displacer type switch using buoyancy principle.
- 2. Switch action shall be mercury switch, form-C contact arrangement.
- 3. All parts shall be 316 or 304 stainless steel.
- 4. Enclosure shall be epoxy coated NEMA 4, or equal.

Acceptable manufacturer:

- 1. Magnetrol Series A15
- 2. Approved equal

lustallation:

- 1. Install in accordance with manufacturer's instructions.
- 2. As specified on the Drawings.

Calibration:

- 1. Set and reset points shall be per Section 17901.
- 2. As specified on the Drawings.

Instrument Identification:	PS
Instrument Function:	Pressure measurement
Instrument Description:	Pressure switch
Power Supply:	NA
Signal Input:	NA
Signal Output:	Contacts
Process Connection:	1/4-inch female NPT.

Product Requirements:

- 1. Construction: Pressure element and a precision switch.
- 2. Pressure element:
  - a. Type: Diaphragm type with Buna-N diaphragm, or brass dual bellows.
  - b. Overpressure: Capable of withstanding 10 times overrange pressure without affecting calibration.
- 3. Switch:
  - a. Hermetically sealed SPDT, unless otherwise specified.
  - b. Contacts rated 10 A at 120 VAC; 0.5 A at 120 VDC, resistive.
  - c. Adjustable set-point and deadband of approximately 10% to 90% of operating range, unless otherwise specified.
- 4. Range: As specified. Set point should fall between 30% and 70% of operating range. Set point and reset point shall be indicated on calibrated scales.
- 5. Accuracy: Repeatability and sensitivity shall be +-1% of operating range or better.
- 6. Enclosure:
  - a. Cast aluminum rated NEMA 4X or NEMA 7, as required.
  - b. Two 3/4-inch conduit connections.

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Acceptable manufacturers:

- 1. Square-D series 9012 G
- 2. Ashcroft LP Series
- 3. Mercoid Series 1000
- 4. Approved equal

#### Installation:

- 1. Install per manufacturer's instructions and the recommendations of API RP550 to the specified requirements.
- 2. Provide root valves at all process pressure taps except taps made for safety instruments.
- 3. Provide gage valves at the instrument where the instrument is not within sight of the root valve or where two or more instruments are connected to a single tap.
- 4. Do not connect safety instruments to the same process tap as instruments used for control, indication, or recording. Unless otherwise specified, locate as close as practical to the process tap and position to permit observation and maintenance.

#### Calibration:

1. Application, calibration, and set points shall be per Section 17901,

Instrument Identification:	PDSH
Instrument Function:	Differential pressure measurement
Instrument Description:	Differential pressure switch, high range
Power Supply:	N/A
Signal Input:	NA
Signal Output:	Contacts
Process Connection:	1/8- or 1/4-inch NPT high and low pressure taps
Product Requirements:	

- 1. Construction: Differential pressure element and a precision switch.
- 2. Pressure element:
  - a. Type: Diaphragm type with Buna-N diaphragm, or as specified
  - b. Overpressure: Capable of withstanding 10 times over range pressure without affecting calibration.

#### 3. Switch:

- a. Snap-action SPDT, unless otherwise specified.
- b. Rated 15 A at 120 VAC
- c. Adjustable set-point and dead band of approximately 10% to 90% of operating range, unless otherwise specified.

- 4. Range: As specified. Set point should fall between 30% and 70% of operating range. Set point and reset point shall be indicated ou calibrated scales.
- 5. Accuracy: Repeatability and sensitivity shall be +-3% of operating range or better.
- 6. Enclosure:
  - a. Cast aluminum NEMA 4X
  - b. NEMA 7 for bazardous areas
  - c. Two 3/4-inch conduit connections

#### Acceptable manufacturers:

- 1. Square-D series 9012G
- 2. Ashcroft series LDA, D400, D700
- 3. Mercoid series PG. SA1100
- 4. Approved equal

#### Installation:

- 1. Install per manufacturer's instructions and the recommendations of API RP551 to the specified requirements.
- 2. Provide root valves at all process pressure taps except taps made for safety instruments.
- 3. Provide gage valves at the instrument where the instrument is not within sight of the root valve or where two or more instruments are connected to a single tap.
- 4. Do not connect safety instruments to the same process tap as instruments used for control, indication, or recording.
- 5. Unless otherwise specified, locate as close as practical to the process tap and position to permit observation and maintenance.

#### Calibration:

1. Application, calibration, and set points shall be per Section 17901.

Instrument Identification:	PDSL1
Instrument Function:	Differential pressure measurement
Instrument Description:	Differential pressure switch, low range
Power Supply:	N/A
Signal Input:	Process
Signal Output:	Contacts
Process Connection:	1/8-inch NPT high and low pressure taps.

Product Requirements:

- 1. Service: Air and non-combustible, compatible gases.
- 2. Wetted Materials: Consult Factory.

- Temperature Limits: -30 to 180°F (-34 to 82.2°C). 1823-00, -20 to 180°F (-28.9 to 82.2°C).
- 4. Pressure Limits: 10 psig (68.95 kPa) continuous, 25 psig (172.4 kPa) surge.
- 5. Switch Type: Single-pole double-throw (SPDT).
- 6. Repeatability: ±2%.
- Electrical Rating: 15 A @ 120-480 VAC, 60 Hz. Resistive 1/8 HP @ 125 VAC, 1/4 HP @ 250 VAC, 60 Hz. De-rate to 10 A for operation at high cycle rates.
- 8. Electrical Connections: 3 screw type, common, normally open and normally closed.
- 9. Process Connections: 1/8" female NPT.
- Mounting Orientation: Diaphragm in vertical position. Consult factory for other position orientations.
- 11. Set Point Adjustment: Screw type inside mounting spud.
- 12. Weight: 1 lb, 5 oz (595 g).
- 13. Agency Approvals: CE, UL, CSA, FM.
- 14. Set Points from 0.07" to 85" w.c.
- 15. Repetitive Accuracy within 2%

#### Acceptable manufacturer:

- 1. Dwyer Series 1800
- 2. Approved equal

#### Installation:

- 1. Install per manufacturer's instructions and the recommendations of API RP550 to the specified requirements.
- 2. Provide root valves at all process pressure taps except taps made for safety instruments.
- 3. Provide gage valves at the instrument where the instrument is not within sight of the root valve or where two or more instruments are connected to a single tap.
- 4. Do not connect safety instruments to the same process tap as instruments used for control, indication, or recording.
- 5. Unless otherwise specified, locate as close as practical to the process tap and position to permit observation and maintenance.

#### Calibration:

1. Application, calibration, and set points shall be per Section 17901.

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Instrument Identification:	PDSL2
Instrument Function:	Differential pressure measurement, low range
Instrument Description:	Differential pressure switch, low range, EP
Power Supply:	N/A
Signal Input:	Process
Signal Output:	Contacts Paragraph 17216.
Process Connection:	1/8-inch NPT high and low pressure taps.

Product Requirements:

- 1. Switch shall be for low range differential pressures, with repetitive accuracy of plus or minus 3 percent of full scale throughout range.
- 2. Service: Air and non-combustible, compatible gases.
- 3. Wetted Materials: Consult factory.
- 4. Temperature Limits: -40 to 140°F (-40 to 60°C); 0 to 140°F (-17.8 to 60°C)for 1950P-8, 15, 25, and 50, -30 to 130°F (-34.4 to 54.4°C) for 1950-02.
- 5 Pressure Limits: Continuous: 1950's 45" w.c. (0.11 bar); 1950P's 35 psi (2.41 bar); 1950P-50 only 70 psi (4.83 bar). Surge: 1950's 10 psi (0.69 bar); 1950P's 50 psi (3.45 bar); 1950P-50 only 90 psi (6.21 bar).
- 6. Enclosure Rating: NEMA 3 (IP54) rain tight, NEMA 7 and 9.
- 7. Switch Type: Single-pole double-throw (SPDT).
- 8. Electrical Rating: 15 A @ 125, 250, 480 VAC, 50 Hz. Resistive 1/8 HP @ 125 VAC, 1/4 HP @ 250 VAC, 60 Hz.
- 9. Electrical Connections: 3 screw type, common, normally open and normally closed.
- 10. Process Connections: 1/8" female NPT.
- 11. Mounting Orientation: Diaphragm in vertical position. Consult factory for other position orientations.
- 12. Set Point Adjustment: Screw type on top of housing.
- 13. CE, UL and CSA listed, FM approved for use in Class I, Div I, Groups C and D, Class II Groups E, F, and G and Class III hazardons atmospheres.
- 14. Weatherproof features include a drain plug and O-ring seal in cover.
- 15. Models offer set points from .03 to 20" w.c. (7.5 to 5 kPa) and from .5 to 60 psi (0.035 to 3.5 bar).

Acceptable manufacturer:

- 1. Dwyer series 1950
- 2. Approved equal

#### Installation:

- 1. Install per manufacturer's instructions and the recommendations of API RP550 to the specified requirements.
- 2. Provide root valves at all process pressure taps except taps made for safety instruments.

- 3. Provide gage valves at the instrument where the instrument is not within sight of the root valve or where two or more instruments are connected to a single tap.
- 4. Do not connect safety instruments to the same process tap as instruments used for control, indication, or recording.
- 5. Unless otherwise specified, locate as close as practical to the process tap and position to permit observation and maintenance.

Calibration:

1. Application, calibration, and set points shall be per Section 17901.

Instrument Identification:	TS						
Instrument Function:	Temperature monitor						
Instrument Description:	Temperature switch, Capillary-type Fluid immersion						
Power Supply:	NA						
Signal Input:	NA						
Signal Output:	Contacts						
Process Connection:	1/2" NPT						

**Product Requirements:** 

- 1. Construction: Liquid-filled bulb and capillary, pressure sensor, susp action switch.
- 2. Bulb and capillary: Material, copper or stainless steel, as specified. Length as needed.
- 3. Pressure element:
  - a. Type: Bourdon tube, copper or stainless steel as required
  - b. Overpressure: Capable of withstanding 300 psi capillary pressure
- 4. Switch:
  - a. General purpose SPDT, unless otherwise specified.
  - b. Rated 10 A at 120 VAC; 0.5 A at 120 VDC.
  - c. Adjustable set-point and dead band of approximately 10% to 90% of operating range, unless otherwise specified.
- 5. Accuracy: Repeatability and sensitivity shall be +-2% of operating range or better.
- 6. Enclosure:
  - a. Cast aluminum NEMA 4X
  - b. NEMA 7 in hazardous areas
  - c. 3/4-inch conduit connections

Acceptable Manufacturers:

1. Ashcroft series L, 400, 700

- 2. Mercoid series D
- 3. Approved equal

## Installation:

- 1. Install per manufacturer's instructions.
- 2. Follow the recommendations of API RP550.
- 3. As shown on the drawings.

Calibration:

1. Application, calibration, and set points shall be per Section 17901.

Instrument Identification:	VS
Instrument Function:	Sense Vibration of Process Equipment
Instrument Description:	Vibration Switch, Electronic
Power Supply:	120 VAC, 60 Hz or 24 VDC, 5 VA max
Sigual Input:	NA
Signal Output:	Triac, PET, 4-20 mA, see below
Process Connection:	Machined surface w/fasteners

Product Requirements:

- 1. Construction: Consists of a self-contained seismic vibration sensor, electronic signal processing and alarm circuitry with two alarm relays.
- 2. Operation:
  - a. Intended to protect rotating machinery from damage due to mechanical malfunction and vibration.
  - b. Signal processing electronics shall convert seismic sensor output into velocity signal, test for alarms, and transmit analog velocity signal.
  - c. Include an alarm inhibit feature that prevents the switch from tripping during machine start up, as indicated by contact closure. After the inhibit period, the switch shall function normally.
  - d. Include an alarm delay feature that prevents the switch from tripping during short term transient vibration conditions. Under continued high vibration the switch shall trip after the delay period. Alarm delay period shall be programmable from 3 to 10 seconds.
- 3. Range:
  - a. Danger alarm set-point: 0.15 to 1.5 inches/sec
  - b. Warning alarm set-point: 10% to 100% of Danger set-point
  - c. Analog signal: 0 to 150% of Danger set-point
- 4. Accuracy: +-5% full scale
- 5. Enclosure:
  - a. Cast aluminum or cast iron NEMA 4X.

- b. NEMA 7 in hazardous areas.
- c. Conduit fittings: 3/4-inch conduit opening for power and signal wiring.
- 6. Signal Output:
  - a. AC powered units: Solid-state triac, rated 2 A at 120 VAC.
  - b. DC powered units: Power FET, rated 3 A at 24 VDC.
  - c. Analog output: 4-20 mA into 0 to 500 Ohms

## Acceptable Manufacturer:

- 1. Rochester model VT-12152b
- 2. Robertshaw model 566
- 3. Approved equal

# Installation:

- 1. Mount and connect per manufacturer's instructions.
- 2. As shown in the Contract Drawings.

Calibration:

1. Application, calibration, and set points shall be per Section 17901.

Instrument	Type	Symbol:	<b>ZS</b> 1
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Instrument Function:	Door position threshold detection.

Instrument Description: N

Magnetic reed switch.

Product Requirements:

- 1. Provide industrial grade switch suitable for harsh environments.
- 2. Contacts: SPDT form C, .5 amp max, 100 VAC/DC max at .25 amps, 7 VA max.
- 3. Magnetic reed switch.
- 4. Prevent sticking or freezing between the two switch plates that form the magnetic field.
- 5. Electrical components hermetically sealed.
- 6. 316 Stainless Steel armored lead type.
- 7. Operating temperature: -40 to 150 degrees F.
- 8. UL llisted.
- 9. Warranty exceeding 10 years for workmanship, material and factory defects.

#### Acceptable manufacturer:

- 1. GE Security Products 2500 series
- 2. George Risk Industries
- 3. Approved equal

Installation:

- 1. Install in accordance with manufacturer's instructions and the application requirements.
- 2. Suitable for metal door installation.

Calibration

1. Per site requirements.

Instrument Type Symbol:	ZS?
Instrument Function:	Position threshold detection.
Instrument Description:	Limit switch.

Product Requirements:

- 1. Configuration as required by the application.
- 2. NEMA rating as required by the application.
- 3. Area classification listing as required by the application.
- 4. Contacts: SPDT, quick make and break, 120 VAC/DC, 20 amps continuous carrying capacity.

Acceptable manufacturer:

- 1. Square D Class 9007
- 2. Allen Bradley
- 3. Approved equal

Installation:

- 1. Install in accordance with manufacturer's instructions.
- 2. Installation and actuation as required by the application.

#### Calibration:

1. Per site and equipment requirements.

# END OF SECTION 17251

## SECTION 17900

#### SCHEDULES

# PART 1 - GENERAL

# 1.01 SUMMARY

- A. Scope: The following schedules are provided:
  - 1. Section 17901: Instrument Schedule (Instrument Index)
  - 2. Section 17903: PLC I/O Schedule
- B. Schedule fields are listed in Part 3.

# 1.02 **REFERENCES**

References to drawing numbers provided in these schedules are provided as a convenience only. An incorrect drawing number or the omission of an appropriate drawing number shall have no impact on the scope of work required under this contract.

# PART 2 - PRODUCTS

## 2.01 SCHEDULES

- A. Data Fields: Schedules shall provide the data columns indicated in Part 3.
- B. Instrument Schedule:
  - This schedule briefly describes major discrete devices required by the control system. Scheduled devices shall be provided as described in the schedules and in the referenced specification paragraph. Each instrument is located by a panel reference or electrical or mechanical plan drawing reference (if field mounted).
  - 2. These schedules shall not be interpreted as a set of complete data sheets for the devices but only as a listing of instruments with certain salient features described. Additional elements such as power supplies, current repeaters or isolators, mounting hardware, cord sets, and other such elements as may be required by a particular vendor in order to complete the system shall be provided even though not listed. The Contractor shall create complete ordering information for all instruments and shall submit this information to the Engineer for review prior to manufacture.
  - 3. Instrument Schedule column descriptions:
    - a. Tag number: These are instrument tag numbers which include the 3-digit instrument loop (IL) numbers and individual instrument prefixes and suffixes, or component name or circuit designation.
    - b. Description: Defines application of the loop or identifies the type of individual instrument within the loop.
    - Specification number: Numbers refer to specification requirements for new instruments which shall be provided.
    - d. Process drawing number (P&Id): Numbers refer to basic process flow drawings showing the schematic locations of primary measuring elements and final control devices within the process.
    - e. Physical location drawing number: Numbers refer to instrument location drawings showing locations for individual field mounted instruments.

# PART 3 - EXECUTION

## 3.01 SECTION 17901 INSTRUMENT SCHEDULE

- A. Column Headings to Include:
  - 1. TAG NUMBER
  - 2. DESCRIPTION
  - 3. P&ID DRAWING NUMBER
  - 4. LOCATION DRAWING NUMBER.
  - 5. SPEC NOMBER
  - 6. CALIBRATION RANGE
  - 7. APPLICATION NOTES

# 3.02 SECTION 17903 PLC I/O SCHEDULE

- A. Column Headings to Include:
  - 1. TAG NUMBER
  - 2. DESCRIPTION
  - 3. P&ID DRAWING NUMBER.
  - 4. PANEL NUMBER
  - 5. I/O TYPE
  - 6. MODULE TYPE
  - 7. RACK
  - 8. SLOT
  - 9. POINT

# END OF SECTION 17900

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Tag Number	Description	P&ID Dwg No.	Physical Location	iPDP Power	Spac. No.	Calib. Range	Application Notes
A-STREAM INFURIENT ST	orage tables (2 of 6)		PC78-N-1-				
PS 901	2. A Stream Storage Influent Header Pressure Switch	202	301	·····	17272	0×50051	***************************************
PE/PIT 901	1 A-Stream Storage Influent Header Pressure Indicating Transmitter	292	301		17243	0-50 psi	
FE/FIT 801	4 IA-Stream Storage Influent Header Flow Indicating Transmitter	2,01	301	120VAC	17241	0-50 gpm	
LEALIT 901	A-Stream Storage #1 Tank Level Indicating Transmitter	201	301	·····	17242	0-35 ft	
A-STREAM INFLUENT ST	ORAGE TANKS (2.01.6)	1	1				
LE/LIT 901	2 A-Stream Storage #2 Tank Level Indicating Transmitter	202	301		17242	0-35 ft	
A STREAM INFLUENT ST	00.4% Tonks (5.07.6)						
LEALIT 901	3 IA-Stream Storege #3 Tank Level Indicating Transmitter	203	301		17242	0-35.ft	
A-STREAM INFLUENT ST	orage tasks (r of 6)						
LE/LIT 901	4 A-Stream Storage #4 Tank Level Indicating Transmitter	204	301		17242	0-35 ft	
A-STREAM INFLUENT ST	ORAGE TANKS (S OF 6	1					
LE/LIT & 904.	5 A-Stream Storzoe #5 Tank Level Indicating Transmitter	205	301	• • • • • • • • • • • • • • • • • • •	17242	0-38 ft	
A-STREAMINFLUERO ST	UPADETANKS 16 OF 61	*			1		
LE/LIT 1 901	6 A-Stream Storage #6 Tank Level indicating Transmitter	206	301	nananananananananananananananananana. 	17242	0-35 tt	an a
A-STREAM RECIRCULAT	GN PUMPS	1					
PE/PIT 902	1 IA-Stream Recirc Pressure Indicating Transpitter	1 207	301		17243	0-50 rst	
FF/FIT 902	1. A-Streem Regize Flow indication Transmitter	767	301	-126VAC	17541	0-300 doto	
AF/AIT 902	1 1A-Shean Reckt Analysisa indicating (committee	267	301	120VAC	17233	1 to 14	
N/SS . CEEN DUKADS					{		al <mark>a an an ann an an ann an ann an ann an a</mark>
50/01 011	1 IN/25 & Train Seed Pump Discharge Pressure Indicating Transatitier	202	301	<u></u>	17223	0.50 00	
100/017 012	Information (Construction) (Construction) (Construction)     Information     Informatio     Information     Information     Information     Information	202	201		17243	A-50 yer	·
1400 A 50 MA	I INKS D Hain reed runn nisonaige riessche nursanng manannes	}		<del>ka niki k</del>	11,675	1 V. C. V. J. GAD 1.	<u>1</u>
IVRS A IRANI	4 BUDD & Tunin Canel Class Instanting Transmitter	1	100	126\(AC)	47544	0.400 apre	
	<ol> <li>IV/NO A Trade Feed flow indicating Transmitter</li> <li>IV/NO A Trade Chatter Mid Manifedra Construct Diffusional Indication Transmitter</li> </ol>	209	202	12017730	17241	0.000 in/H0n	
	<ol> <li>DVRC A Train Subper Miss granitation Pressure Dimensional morearing transmitter</li> <li>DVRC A State Pressure Types Operating Defension I subsches Types without</li> </ol>	205	302	÷	17242	0.00 10/120	<u> </u>
	2 IV/NO-5 / Tast Support Trays Pressure Differential Indicating Transmitter	203	<u> </u>		17275	0.50 jp/H2o	
LCAL! ( 97)	3 HVRS A Han Supplet Sump Pressure Unterclinear Indicating Hanstones	209	302	<u></u>	17245	0.200 (a/-32a	
PUC/PUCIE 97.1	- 0.1 MVR3 A Train olower Pressure Differential indicating, Paristriater	209	302		17242	0-200 10/1120	
IVAS - 6- 3KAM3	A MAR MITTLE FILL FILL BALLER COLLEGE		050	4000/60	47840	0.400	
FE/FIL 912	<ul> <li>AvxS P Train reed how indicating transmitter</li> </ul>	210	302	120720	17241	0 202 in U2a	
PUE/PUIT 812 1	<ol> <li>DVPAD E. 0460 200906 MIST COMPLEXIT Pressure Conferences (00)22013 (D2000000000000000000000000000000000000</li></ol>	2337	302		17243	0.66040.00	
numum siz	2 INVES & Hast Supper Hays Pressure Dimeterinal ingloading Hastonber	210	302		17240	0-50 m/F120	
CRAPT 992	3 (IVRS B I fain Supplet Sump Pressure Uniterential Indicating Transmitter	210	{ <u>302</u>		17240	0.000 0000	
PU8/PO59 912	51. (DVKS B 1780) blower messure Differential Indicating Hansinsteer	4	{		17240	0-200 39/120	
TO TE CONTRO	1 DOT FLIGHT THEY CANNER THE STREET	1	203		47740	0454	
1.6701 920	<ul> <li>Frid Feed A (160.150), Development (180.000) (180.000)</li> <li>LOTO Frid B Tark Land Land Adamter Transmitter</li> </ul>	4.44	000		47545	Q-1011	
NOC FERRE CONTRACTOR	A STARTER B TRADITION TOWN FOR THE START TRADUCT		203		11246	U-(011	
MASSING CONTRACT	Otto A Train Trank Than Investigation Training the		<u> </u>	12/5/00	47044	S 500 apr	
<u>. COUCH Y 521</u>	<ul> <li>A TRO A TRUE REPAIRED MARKING TAXANGUT</li> <li>1000 A TruE Repaired Marking TaxangUt</li> </ul>	215	- 503 ane	INUVAL.	1241	0-100- <u>91</u> /01	Experimental and the second s
FEUEL 600	CITO A HER PICESUL INDICEDING LEEPSING	413	303	\$200780	11290	0.100	
DE/DIT 200	1002 Contracting transmission and a contraction of the contraction of	415	203	12.9 KM	1/24	o tou gom	
776/F11   922	i invo o rish messure lookaling hansmitter	213	303		1/243	0-30-551	
EROCHAN DEGMER DEGMERT	( 10) (* 14) 15) November 18 (19) 11 ( 19) 11 (19) 12 (19) 12 (19) 13 (19) 15 (19) 15 (19) 15 (19) 15 (19) 15 (19) 15 (19) 15 (19)		500	4 0 0 ( A / S	4704.	2 EQ mart	
(C/LC) 820	Z JEND A HAIN LINE FIZSE LARK FEEL FIGH (SECOND HAINS) (SASINGEL	41 2.19. 	2009	1231VAU	17043	0.12.9	
LC/L/1 / 827.	I PROMITION LINE FREE LARK LEVEL INCLUDING TONSMILLET	£	209	1	11242	32-10 N	Tue Orders in Single Transmitter, Tue Angles Contracts
AC/A!! 521	<ul> <li>a) press A (rate Line Fillso ( ank Analytical (notosting ) ransmitter</li> <li>b) to b ( the line line dependent to the start of the line if the start of the line if the start of the</li></ul>	234	<u> </u>	NUVAC :	1.431	1 10 14	Transmission of the second strategies and th
LR/UI 1 921	2 ICING A ITEIN LINIE KERCEUN (ENK LEVELINGKERTUG) (TRINSIGNET	1 234	609		1/242	0-10 R	
RS A TOAIN MELANED	PLATE LLARIFIER	4 maria	<u> </u>			0100	100 Marsh Distanting States Casta Octavity (State
1.1:/11 921	5 Prixs A i ram IHC Level Indicating transmitter		308	LOVAC	na Arices	U-1070	Isinotia malaction system, your wusing chitpuss, switt
http:// 1 921 1	3 Prix's A Lisen Indi Civernew Flow Indicating Lisensmitter	3 - 235	503 1	120VAC	1/241		S.

Tag Nomi	ber		Description	P&ID Dwg No.	Physical Location	iPDP Power	Spec. No.	Calib. Range	Application Notes
PRS - A TRAIN IDC S	SLUDG	5. FUN	95						
LSH 1: 921	1		PRS A Train IPC Sluitge #1 Pump Leval Switch High	216	303		69	na	Leak Detector Supplied with Pump
PE/PIT \$21	1	11	PRS A Train IPC Studge 21 Futop Pressure Indicating Transmister	22.6	305	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	17243	0-50 esi	
LSH 921	1	2	PRS A Train IFC Sludge #2 Pump Level Switch High	216	303		na	na	Leak Detector Supplied with Pump
PE/PIT 921	1	12	PRS A Train IPC Studge #5 Pump Pressure Indicating Transmitter	216	303		17243	0-50 psi	
FE/FIT 921	1 1	4	PRS A Train IPC Sludge Flow Indicating Transmitter	216	303	120VAC	17241	0-20.gem	
ORS - B TRAIN LIME	E REAL	CON-	ANKS						
FE/FIT 922	2	2	PRS B Train Lime Flash Tank Feed Flow indicating Transmitter	217	309	120VAC	17241	0-50 gpm	
1.E/LIT 922	2	1	PRS 8 Train Limo Flach Tank Level (odication) Transmitter	2.17	309	120VAC	17242	0-10 m	Uitrasonic
AE/AIT 922	2		PRS & Train Lime Flash Tank Analytical Indicating Transmitter	. 217	309	120VAC	17231	1 10 14	Two Probes to Single Transmitter, Two Analog Outputs
LE/LJT   922	21	2	PRSS Tron Lone Roaction Tank Level Indicating Transmitter	217	303	120VAC	17242	6-10 ft	Ultrasonic
FRS- B TRAIN MCC	0010	1ATE C	LARIFIER	1					
LE/LIT : 922	2 1	3	PRS 8 Train IPC Lavel ladicating Transmitter	218	309	120VAC	17242	0-10 ft	Sludge Detection System, Four Analog Outputs
TE/FIT 922	2	3	PRS 8 Train IPC Overflow Flow Indicating Pransmitter	2.18	303	120VAC	17241	0-100 gpm	
PRS - B TRAIN IPC S	SEUDG	EPUM	PS	7					
1.58 923	2 1	منتخب الم 1	PRS 8 Train IPC Studge #1 Pump Level Switch High	219	303	a da la caracteria de la c	503	57	Usek Detector Supplied with Puna
PE/PIT 922	2		PRS 8 Train IPC Sludios #1 Pumo Pressure Indicating Transmitter	219	303		17243	0 to 20	lisolating Diaphragm
LSH 922	2	2	PRS 8 Train IPC Studge #2 Pump Level System High	215	303		na	na	Resk Detector Subskied with Public
PE/P(T 922	2	12	PRS & Train IPC Studge #2 Pump Pressure Indication Transmitter	219	303		17243	140 D2-0	Hisolisona Displozam
FE/EIT 922	2 3	<u>A</u>	PRS & Train IPC Sludge Flow indicating Transmitter	219	303	120VAC	17241	0-20 com	a <b>de antes de la companya de la comp 1 1</b>
6 65 SUDDE 1705		TANKS	· · · · · · · · · · · · · · · · · · ·		*******				
	بتتبنك		PRS Filter Press Feed A Train Slugge Tank Level Indization Transmitter	220	304	120VAC	17242	0-15 ft	Ultrasonic
7 F/T av2	5		PRS Filter Press Feed & Train Studio Tank Level Autoarity Transmitter	220	304	120VAC	17242	0-15 ft	Ukcesowic
ANG FILTER ORFS	Geren	POWP		-}				******	
ISH 1 923	3		PRS Filter Press Feed A Train Pomo Level Switch Blob	221	304	فاستناه والمتعادية بالمراجعة	113	03	Leak Detector Supplifed with Pump
92/Pff 923		1	PRS Filter Press Foed A Train Proton Pressure Indicating Transmitter	221	304	****	17243	0-200 osi	Usulating Dicentration
ISH 923			PRS Filter Press Feed 8 Train Fund Level Switch Midd	221	304		86	38	Peak Detector Supplied with Funds
PE/PIT 423	3 3	i i i i i i i i i i i i i i i i i i i	983 Filter Press Freed & Train Planto Pressure Indication Transmitter	221	304		17243	0-200 nsi	Tradition Discover
191 223	ž t		PRS Filter Press Feed Natural Varia Lave Switch Hat	221	304	ذمرمتم تعريم بمرجوه مست	08	 79	Leob Obbecay Scoules with Passo
PE/PIT 023	Ť		PRS Filter Press Feed Standby Pump Pressure Industrial Lansmiller		304		17243	0-200 nsi	Isolathic Diann ann
PRS A TRANSPOT	FR PR					وموجوع ومرود والمرود و			
FE/FIE 924		بربيعي	PRS Filler Press & Tralo Filtrale Flow Indication Transauliter	7.6	310	120VAC	17241	0-15 gem	
AF/AIT 924	֠	ومتعمدهم	PRS Filter Press & Trate Efficies Supported Solids Againtical Indication Transmitter		310	120VAC	17231	0-100 ma/L	Recuires Flush Water
COS . O TRAIN SUTS	5	ببببنين		~		••••			<b>1</b>
FF/FIT 1 925	5		PRS Filter Press & Login Filtrate Flow Indication Transmitter	224	310	126VAC	17241	0-15 apor	***************************************
AF/A01 925	المنطقة		PRS Futer Press B Train Fibrate Suspended Source Analytical Indication Transmitter	274	310	120VAC	17231	0-100 ma/L	Remires Sitch Water
ASPS - FEFO TANKA	أتبعينه				****				
15411 G90	5	فكفيفينية	MPS Feerl & Train Tank ( ever lociez/ing Transmitter	225	304		17242	6.12 ft	
15455 030	<u>ă</u> -+	2	MPS Fead 8 Train Tack Level Judgating Transmitter	274	303		17242	0 12 ft	
MARS - KEEN OF MARS	<u> </u>			*******			*****		
FF/5/T 931			MPS A Train Feed Flow Indicating Transolities	275	304	120VAC	17241	9-100 April	
200/201 211		مىمىنىيەت. 1	1998 A Train Schel Dream as Indication Wattering	77:	304		17243	0.50 osi	
		÷	M90 8 Train Card Sing Midiralist Teneroliter	775	304	128VAC	17241	0-100 חמנה	
002 002	2		MPS B Train Feed Pressure Indicating Transmitter	225	304		17243	0-50 nai	
APRIL & TRATE LISS		CTO ON	nen (g. 20. oktober), et versen et der Berner op 1979 (d. 2019) (d. 2019) Andere en		<u></u>				
PART OF ANY	(	- <u></u> ]	MPS: A Train Line Flash York Lovel Indication Transmitter	225	313	COVAC	17:42	0.10.0	Whizsonic
16/11 024	;+		MPS & Train Lime Reaction Tank Level Indication Liabsonitier	226	311	120VAC	17242	0.10.#	litinasonio
AC/AIT 024	÷	أخديتهم	1998 a Testa Fine Frankrik Tany it an Anatonical Internet Transmiser	256	311	120VAD	17231	1 10 14	Two Probes to Signle Transmitter, Two Avaion Divisids
MARK LA THEIN CON			тер, ак у также у жили сомистики срадок то сулски симурани. Каканала у у такаха дара	1					
MIGU 024	1 1		MPS & Train Finandating Clasifier Rake Torona Architest Indication Transmitter	1 227	311		na	na	WSH/WSHH Torous Switches Supplied with Oterifier
- 440ET - 1- 20	<u>.</u>		MARKET AND LARGENEED AND AND AND AND AND AND AND AND AND AN		البيستناسية	ليحصب محمدهم	أمورو ويتبعث المتحد المتحد المحد	****	The second s

Tag Number			Description		Physical Location	IPDP Power	Spec. No.	Calib. Range	Application Notes
LEAR I	931	( s	IMPS A Train Electrosting Clarifier Level Indicating Transmitter	227	311	120VAC	17242	0-15 ft	Sludge Detection System, Four Analog Outputs
AE/AIT	331	ستبد	MPS A Train Flocoulating Clerifier Ovenlag pH Ansimiles Indicating Transmitter	227	311	120VAC	17231	1 to 14	• • • • • • • • • • • • • • • • • • •
FEART	931	2	MPS A Train Nonalizing Clerifier Overflow Flow indicating Transmitter	227.	311	120VAC	17241	0-200 gpm	
MPS - 8 TR-	IN LIME REA	ACTION	1		1	1			
LE/LIT	932	1	MPS 9 Train Line Pash Tank Level Indicating Transporter	228	311	120VAC	17242	0-10 ft	[Ultrasonic
LEADY 1	932	2	MPS 8 Train Lime Reaction Tank Level Indicating Transmitter	228	311	120VAC	17242	0~10 ft	Ultraspoid
AEJAN	932	<u>}</u>	MPS & Train Lime Reaction Tank #1 phi Attalytical Indicating Transmitter	228	311	120VAC	17231	1 to 14	Two Probes to Single Transmitter, Two Analog Outputs
MP5 - 6 102	WN SQUEDSS	ETTUN	G		[	[			
1484	932	51	IMP5 & Train Elocutation Claufier Rake Torque Analytical indicating Transmitter	229	311	[	na .	na	· · · · · · · · · · · · · · · · · · ·
LE/LIT	932	3.	MPS 8 Train Placoulating Clarifier Level Indicating Transmitter	229	3:1	120VAC	17242	0-15 ft	Starge Oeteotian System, Four Analog Outputs
AE/AIT	932	3	MPS 8 Train Placedosing Clarifier Overflow pH Analytical Indicating Transmitter	225	311	120VAC	17231	1 10 14	
FE/FIT	232	2	MPS B Train Flooridoting Clerifier Overflow Flow Indicating Transmitter	229	311	120VAC	17241	0-200 gpm	
MP5 - CLAR	FIED WATE	RITANK			1				
CEAN I	\$33		MPS Clarified Water Tank Level Indicating Transmitter	230	308		17242	0-15 H	
FE/FIT	936	1	MPS Filter Press A Train Filtrate Flow Undicating Transmitter	230	312	120VAC	17241	0-50 gpm	· · · · · · · · · · · · · · · · · · ·
AE/AIT	938	1	IMFS Filter Press A Train Filtrate Suspended Solids Analytical Indicating Transmitter	230	312	120VAC	17231	0-100 mg/L	Requires Filesh Wote:
FE/FIT	937		IMPS Filter Press B. Train Fibrate Flow Indicating Transmitter	230	312	120VAC	17241	0-50 gpm	
AL/ALT	937		MPS Filter Press 8 Train Filtrate Suspended Solids Analytical Indicating Transmitter	230	312	120VAC	17231	0-160 mg/.	Requires Flush Water
APS-CLAR	FIED WATE	BPUM	PS & BAG PRITERS	[	1	1	[		
PE/PIT	933	1	1998 Clarified Water Pressure indicating Transmitter	231	308		17243	0-50 psi	
SE/FOT	933		IMPS Clarified Water Flow Indicating Transmitter	231	308	120VAC	17241	0-800 gpm	
MES-CLAR	FICO WATE	TAN	BOTTOMS PUMPS			<b>[</b>			
1.58	933	4	IMPS Clerified Water Trank Boltoms #1 Porns Level Switch High	232	308		503	ha	Leak Detector Supplied with Pump
PE/PIT	953	4	1449S Clarified Water Tank Bottoms \$1 Ports Pressure Indicating Transmitter	232	308	[	17243	0-15 ps:	biolebrá Dielofrágm
LSH	933	1.5	IMPS Clautied Water Tank Boltoma #2 Pomp Level Switch High	232	308	[	09, 11		Lesk Detector Supplied work Puntp
PE/PIT	933	137	MPS Clanties Water Tank Sottoms #2 Pump Pressure Indicating Transmitter	232	308	{	17243	0-15 Ra	Uscisting Displyagen
PENER.	235	$\frac{1}{2}$	IMPS Clanties Water Tank Bottoms Flow todicating Transmitter	232	368	120VAC	17241	0-50 gpm	
IMPS SLUDG	e storage	M.S	LUDGE PUMPS	<b>.</b>	1	1		[	
1.34	934	1	IMPS: Studie Storage gransfer from A Train FLC) Plano Loval Switch High	233	307	}	па	[	Leak Detector Supplied with Pump
PE/PIT	934	1	(MPS Studge Storage (transfer inton A Train FLC) Pressure indicating Transmider	233	307		17243	C-15 pm	Recisions Desplayers
E LSH	934	2	13/PS Slugge Storage (Iransfer from B Train FLC) Pump Level Skilloh High	233	307	1	na		Lesk Detector Scipilial with Porton
119E/917	934	2	MPS Studge Storage (provider from 8 Train FLC) Pressure Indicating Transorator	233	307		17243	0-15 pa	lisoisting Displyage
frank starter	934	3	MPS Studge Starsge (transfer from FLC) Startby Pump Level Switch High	233	307	1	na		Leak Detector Supplied with Pump
PE/PIT	934		16PS Studye Storage (transfer from FLS) Storaby Plana: Pressure Indicating Transmitter I	233	307	1	17243	3-15 psi	jistileding Displotaçan
MPS SCUDG	E STORAGE	TANKS			1	1			
FE/FIT	934	1.3	[MP6 Studge Storage (Reporter trun; A Train FLC) Flow Insteating Transmitter	234	308	120VAC	17241	0-50 gpm	
LE/LIT	534	1	IMPS, Studge Storage A Train Tank Loval Industring Transmitter	234	308	120VAC	17242	C-15 H	Ukrasimiz
FE/FIT	934	2	MPS Sludge Storage (transfer from 8 Train FLC) Flow indicating Transmitter	234	308	120VAC	17241	0-50 gpm	
LEADT	934	177	WPS Shidge Storage B Train Fork Level indicating Transmitter	234	308	120VAC	17242	6-15 ft	Entresone
MPS FUTER	PRESS PEED	}			1				
LSH	\$35	T	MPS Filter Press Feed A Train Pump Level Switch High	235	308	[	na	na	Leak Detector Supplied with Funjo
Server	905	3	MPS Filter Press Feed A Train Pump Pressure Indicating Transmitter	235	308		17243	0-200 ps)	lisolating Diaphragm
LSH	935	2	MPS Filter Press Féed & Trom Purity Level Switch High	235	306	1	na na	เาอ	Leak Detector Suppled with Publo
PE/PIT	935		MPS Filter Press Feed B Train Prossure Indicating Transmitter	235	306		17243	0-200 059	Beoleting Disphragm
LSH	935	3	MPS Filter Press Feed Standby Flatts Level Switch High	235	308		ria	na	Heak Cataotor Supplied with Partie
PE/PIT	935	3	MPS Filter Press Feed Standoy Pump Pressure Intitoding Transmitter	235	308		17243	0-200 pei	Jecteting Dischologia
LGAC PRED	(1 OF 2)	<b>[</b>							1
LE/LIT	970	1	LISAC Fred of Fool Level Indicating Tradiantilian	238	\$05		17242	0-35 ft	Land contract of the second second
16ACTOR	0.04.2	Γ						[	
LEAD	970	2	LCAC Foet #2 Tank Level Indicating Transmitter	239	306	]	17242	0-35 ft	

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Tag Number	Description	P&iD Dwg No.	Physical Location	IPDP Power	5pec. No.	Colib. Rongo	Application Notes
LGAC FEED PUMPS							
PE/PIT 970 1	REAC Feed Feed Pressure Indicating Transmitter	240	305		17243	0-50 psi	······································
FE/FTC 1 970 1	3LGAC Feed Feed Flow Indicating Transmitter	240	305	120VAC	17241	0-400 opm	······
AE/AIT 970 3	ILGAC Feed Feed Analytical Indicating Transmitter	240	305	120VAC	17231	1 to 14	
LGAC SYSTEM - VESSEL HI		*********					3
REART 971 1	It GAC System Supply Water Firm Industring Transmitter	52.1	305	120VAC	17241	0-10:00 ითლ	1
CAC SYSTEM VALVE MALOF	$\mathbf{r}_{0}$		<u>}</u>				
PE/PIT   971   1	I GAC System Vessel 21 Pressure Indicating Transmitter	242	305		17243	0-150 osi	f
202/2011 071 1	I GAC System Vessel #1 Pressure Differential Individuation Transmitter	240	305		17213	0.500 061	
DE/011 074 0	UCAC System Vescal #2 Practice infinition Transmitter	247	305		17243	0-150 06	
	UCAC Custom Voucel #2 Construct Differential Indication Technolities	243	206		47243	0.500 cci	
	Acone dystem vesser wz messere binerentar procestig mananitier	244.2	305	<u></u>	11243	0-000 pai	<u></u>
10010 0151EW - VE55EL #2	4					*****	{{
		}					<u> </u>
COAC BALKWASH JANK	l marte million de Million I de Carden de Marte de Marte	<b></b>					
CE7LII 1 972 1 1	ILGAC Backwash Tank Level Indicating Transmitter	<u> </u>	305		17242	υ-35 π	<u>}</u>
LGAC BACKWASH PUMPS		ļ					
PF/PT 972 1	ILGAC Backwash Side Draw Transfer Pressure Indicating Transmitter	245	305		17243	0-30 psr	
FE/FIT 972 1	ILGAC Backwash Side Draw Transfer Flow Indicating Transmitter	245	306	126VAC	17241	0-200 gom	
LSH 972 2A	RIGAC Sectorash Bottom Draw Transfer A Pump Level Switch Figh	245	306		na	517	Leak Detector Supplifed with Pump
PE/PIT 372 2A	ILGAC Backwash Boltom Draw Transfer A Pump Pressure Indicating Transmitter	245	306		17243	0-30 psi	jisolating Diaphration
FE/FIT 972 2A	LGAD Backwash Bottom Draw Transfer A Psinto Flow Indications Transmitter	246	306	120VAC	17241	0-100 gpm	
LSH 972 28	LGAC Backwash Bottom Draw Transfer B Pump Level Switch High	246	309		na	00	Leak Detector Supplied with Pump
PE/PIT 972 2B	LGAC Backwash Bottom Draw Transfer & Pump Pressure Indicating Transmitter	246	305		17243	0-30 bsi	lisidatarg Ciardicagra
FE/FIT 972 28	EGAC Backwash Bottom Draw Transfer B Pump Flow Indicating Transmitter	246	306	i	17241	0.100.000	
WEST - SHOE SUMP							
AE/AIT 980 1	Sump. West - Side pH Anelyticat Indicating Transmitter		302	120VAC	17231	1 to 14	· · · · · · · · · · · · · · · · · · ·
LE/LIT 960 1	Sumo: West - Side Level Indication Transmitter	247	302	120VAC	17242	0-15 ft	Submersibe Leval Element
PE/PIT 980 1	Some West- Side Fumo Olachanga Pressure Indicating Transolition	247	302		17243	0-50 ps	
CAST - SIDE SUMP							
AE/AIT 981 1	Sump East - Side of Ansistical Indicating Transmitter	248	306	120VAC -	17231	1 to 14	
1F/IT 981 1	ISunto, Esst - Side Usvel Indicating Transmitter	248	306	120VAC	17242	0-15 ft	Submersithe Level Element
P6/011 981 1	Simn East - Side Pump Discharge Pressure Indicating Transpitter	248	305		17243	6-50 ost	
CAST/AVECT SUISAD DIVEDSI/3N		<b>}</b>					
FF/FIT ASS 1	Sumn Most Side Flour Indination Transmitter	249	302	120VAC	17741	G-19Bonizi	***************************************
AUSTREASS ADVA SUMAD							ff
(570 07 090 4		260	301	1201/46	17040	0-15.9	Nidtmersdna Lavel Siament
012/017 000 A	Touring, West "Arounder Area Sume #1 Dump Pressure Industrian Transmitter	150	361		17242	0-50 nei	
	Touring, West - A Shoop Ando Sures #2 During Pressure Indicating Transmitter	100	1 201	····	17542	0-50 ps; 0-50 ps;	ff.
7 57 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	Torinity, these - moduled metal control manufactures inducating manufactures		{iiii		11 2 44 3		
TOUS DOUD	19		204	100120	17040	0 45 6	Communities ( and Claman)
- 127411 - 950 - 0 - 126 - 126 - 126	Action Must Mile Cool Area Company Provention Contract Interface	43			47049	0.00	CONCIDENTIAL LEVEL EVEL (1011)
<u> </u>	Country Vest And Freed Area Sump A) Pump Pressure indicating intersenter	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	{		11240	0-56 851	{
rc/mii   980 } 7	Tomut Area - who lead the other to the leader indicated indinated indicated indicated indicated indicated indicated	102	<u>م</u> ريد الم		1/243	U-30 (55)	<u> </u>
PRO HILTER PRESS SUMP			{	4001213	47/010		l
LEALY 980 8	15umo, vyest - Miks Hitter Press Sump Level Indicating Hansmitter	1	304	TZUVAC	37292	0-137	lorotostabos rekai rietueki
PE/PIT 980 8	Tourne, West - Mixis Hiller Press Sumplif" Furth Pressure Jobocoung Transporter	J	304		11243	0-50 psi	<u> </u>
FE/PIT \$20 3	Journo, West - Mrus Hilter Press, Stanto WS Murito Pressure Indicating (1988) Ministri	252	304		37243	0-50 081	<b>}</b>
LEAC AREA SUMPS	1	••••••••••••••••••••••••••••••••••••••					<u>}</u>
LE/LIT 981 4	1Sump, East - LGAC Area Sump Level Indicating Transmitter	253	306	120VAC	17242	0-15 ft	Supmeralibé Level Element
PE/FIT 981 4	Nump East - LOAC Area Sump \$1 Pump Pressure Induceding Transmitter	253	306		17243	0-50 psi	}
PE/PIT 981 5	Sump, East - LGAC Area Sump #2 Pump Pressure indicating Transmitter	253	306		17243	9-50 psi	La construction de la construction

Tag Number			Description		Physical Location	IPDP Power	Spec. No.	Calib. Range	Application Notes
MPS FLOCO	ULATING CL	ABIRIER	lapea sump		{······			<u>}</u>	1
LE/L)T	981	-3	Sump; East - MPS FLC Area Sumo Level Indicating Transmitter	254	307	120VAC	17242	0-15 1	Submersilbe Level Ejement
PE/PIT	981	5	Sump, East - MPS FLC Area Sump #1 Pump Pressure Indicating Transmitter	254	307		17243	0-50 psi	a secondaria da secondaria Escandaria da secondaria
PE/PIT		7	Sump, East - MPS FLC Area Sump #2 Pump Pressure Indicating Transmitter	254	307		17243	0-50 psi	
MP5 FUTRA	TE AREA SU	MP			1				
1.E.G. (T.	981	. 3	Sump, East - MPS Filtrate Area Sump Level Indicating Transmitter	255	305	120VAC	17242	0-15 ft	Submersilbe Level Element
PE/PIT	983	8	Sump East - MPS Forste Area Sump #1 Pump Pressure Indicating Transmitter		308		17243	0-50 psi	· · · · · · · · · · · · · · · · · · ·
PE/P(T	981	9	Sump, East - MPS Filbate Area Sump #2 Pump Pressure Indicating Transmitter	255	308	*****	17243	0-50 psi	
MESPHITER	PRESS SUM	P			]				
LE/LIT	981	-10	Sump, East - MPS Filter Press Sump Level Indicating Transmitter	256	305	120VAC	17242	0-15 ft	Submersilbe Level Element
PE/PIT	\$91	10	Sump, East - MPS Filler Press Sump #1 Pump Pressure Indicating Transmitter	256	308	*****	17243	0-50 psi	
<u>na/34</u>	981	. 13	Sump, East - MPS Fifter Press Sump #2 Pump Pressure Indicating Transmitter	256	308		17243	0-50 psi	
PROCESS W	ATER DISTR	SUTIO	N HEADER (REVISION OR ADDITION TO 9TP DRAWING)		}				
PE/PIT	983	1	Frocess Water PCTF Header Pressure Indicating Transmitter	260	305	******	17243	0-103 os:	
FEJEIT	983	**************************************	Process Water PCTF Header Flow Indicating Transmitter	260	305	120VAC	17241	0-1000 gpm:	
AIR GAR W.	Area FANS	ANOP	CAPE.				******		
LE/LIT	984	لالدينانياني ا	Air Gap Watar Tank Level Indicating Transmitter	261	305	****	17242	0-35 ft	<b></b>
PE/Pff	984		Air Gap Water Pump Discharge Pressure Indicating Transmitter	261	305		17243	0-100 psi	
FE/FIT	984	1	Air Gan Water To PCTF Flow indicating Transmitter	262	305	120VAC	17241	0-300 gpm	**************************************
AR GAP W	ATER - HOSE	818 64/	ANGOLL:					**************************************	
		*****			1			******	
WIGH PRESS	UREWATER	******	1		****				
		valatatatata.			1				
SAFETY WAS	TER SYSTEM		1				ور ور الدائدة البالية اليالي الي الي الي الي الي الي الي الي		**************************************
TEATH	985	لنندننا	Safety Water System WCH Temperature Indicating Transmitter	254	305		17245	0-200 deg F	in an
53	985		ISafery Water System WCH Flow Switch High	264	305	*****	17251	03	
TENT	985		Satery Water System WCH Temperature Indicating Transmitter	264	305		17245	0-100 deo F	<b></b>
	985		ISafaty Water System WCC Flow Switch Low	264	305		17251	na	
IMS FEED	WST2N				305				·····
( #// m	627	ومزعز عادمتهم	i me Feed Tank Level Indication Transmitter	265	308	120V/AC	17242	0-10 ft	Ultrasonic
27/017	927 927		li ine Faed to ORS A Train Pressure Indicating Transmitter	265	508		17233	3-50 osi	Isolating Diantifating
		h	ti ima Faad in 989 A Train Level Switch High		306			05	Lesk Detector Supplied with Pump
DC/DIT	0.97		Lima Faad to PRS R Train Pressure indicating Transmitter		305		17213	6.50 184	listania Zisubrano
Shi -	397	بنبشب	I the Cast to DRS 8 Train Level Switch High	266	306		na		I eak Detector Supplied with Purry
DE/DIT	647	*****	If ima Cool of PS Stanthy Pressure Indication Transmitter	266	306		17:43	0-60 asi	Generation Connected in 202
1.51	027		I ima Seed to PBS & Train Level Switch Hinh	266	306	• • • •	na tra	118	Reak Detector Supplied with Plann Not Connected to PLC
05 /017	007		(Finite Food to MRS & Train Pressure indication Transmitter	2<7	106	, ninininininininininininininininininini	17243	6-50 nat	Evolution Olizobiano.
5	0.27	بينينهم	It in a Food in MOS & Train + ever Switch High		306		na	na	Heak Detector Supplied with Pump
PF/Dir	997. 987.		If the Feed to MPS B Trait Pressure Indicating Transmitter		306		17243	6-50 pel	Hsolating Diaphragm
Su -		12	I ime Feed to MPS 8 Train Level Switch High	267	306	****		har na	I eax Detector Supplied with Pump
	 997		I ine Seed MPS Standby Pressure Indication Transmitter	267	306		17243	6-50 nsi	Esclating Diaphreere, Not Contracted to PLC
<u></u>	097	12	li ina Sood to MPS B Trato Level Switch High	767	308		p.2	112	Li sak Detector Supplied with Pitron blot Connected in PI C
1201 1203 A210 A A	50; (XA)(6626.4	Seres?	Sector Freedow MP, A 22 (1997) Sector Content (1998)		{			\$	
incinisi (4N		معمد تدري محمد تدريخ	*****		<del>}</del>		مركر المالم المالم المالية المالية المراجع المراجع الم	£	ł
005 00 44			{		<u> </u>				
55752.3N	2X - 2 MAD 201	•••••	Polymer Cred Ourtern DOS A. Train Oppring Whitter Practicula Custors Lines		203	1201/20	17241	0-10 mb	***************************************
	331 coo ro ***		A BARREL LEGS OFFICIALLE AND ALLINE LICENS AND LEASEN CONTROL FOR			120770			<u>}</u>
rear NO. YN	25 3 33.48		1. Delawar Sand Contain 200 B. Train Dename Water Processes Quiteb Law	~~ <u>*</u> ~~~~~	203	120 (AC	17241	0.10 oph	••••••••••••••••••••••••••••••••••••••
1*7./*	NAG.		Troyner reed bystem mad an i isin anocess system ressure byston Low.	2/1	- 000 	1201240	17441	1 0-10 Q(m	}
000300050 535 0000	ARCA: 533		1 Debrary Frank Statem MDG & Turk, Darage Mathe Darage South Law			1003/071	17:244	0 dti asis	}
rc/511	993	<u></u>	provimer need bysiem wind A-Train Process Anster Micessine Review Fow		2	LIZUVAG	11241	1 0-10 gpg	Lange and the second

MPS POLYARE STRAIN	Tag Number	Description	P&ID Dwg No.	Physics/ Location	IPDP Power	Spec. No.	Calib, Range	Application Netwo
	MPS POLYMER - EDRAM							
FERTI ESC 1 POWHER PLAN SYMPTOTICS WAS PROSENCE SANCE LOW 12/3 305 125 VAL 12/241 0-10 500	FE/FIT 894	Polymer Faco System MPS B-Train Process Water Pressure Switch Low	273	303	12SVAC	37241	0-10 gon	