

## SECTION 40 60 05

### INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

#### PART 1 – GENERAL

##### 1.1 DESCRIPTION

###### A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish, install, calibrate, test, start-up, and place in satisfactory operation a complete and operating Instrumentation and Control system for the Pump Station. The Instrumentation and Control system shall be designated as Pump Station Control System (PSCS).
2. Major components of the PSCS include:
  - a. Pump Station Control Panel with
    - Programmable Logic Controller (PLC)
    - Operator Interface Terminals (OIT) mounted on the face of the control panel.
    - Cellular Router for connectivity back to the Water Treatment Plant (WTP)
    - System human-machine interface (HMI) software.
    - Uninterruptible power supply.
  - b. Field instruments.

###### B. Coordination:

1. Instrumentation and Controls:
  - a. Instrumentation and Control Equipment shown and specified herein is expected to be furnished, installed, and placed into satisfactory operation by an Instrumentation and Controls (I&C) Subcontractor.
  - b. Programming of control logic and configuration of HMI software is not part of the Work and is by OWNER assigned Programmer.
  - c. Some panels and equipment are furnished under other Specification Sections under this Contract. CONTRACTOR shall coordinate with Suppliers of these panels and equipment to provide fully functional system in accordance with the Contract Documents and that interfaces with PSCS.
2. To centralize responsibility, materials and equipment provided under this Section shall be furnished by a single I&C Subcontractor.
3. With CONTRACTOR, I&C Subcontractor shall assume the responsibility for adequacy and performance of materials and equipment provided under this Section.
4. To the greatest extent possible, provide materials and equipment from a single manufacturer.
5. I&C Subcontractor's Responsibilities:

- a. Preparing all instrumentation and control equipment submittals in accordance with the Contract Documents.
- b. Proper interfacing of instrumentation and control equipment with field equipment, instruments, devices, and panels, including required interfacing with packaged control systems furnished by other equipment Suppliers, and required interfacing with the Site's electrical system.
- c. Review and coordination with manufacturers, Suppliers, and other I&C Subcontractor submittals for equipment, valves, piping, and appurtenances for ensuring proper interfacing of hardware, and locations and installation requirements of inline devices and instrument taps.
- d. Direct, detailed oversight of installation of instruments, panels, consoles, cabinets, wiring and other components, and related wiring and piping connections.
- e. Calibrating, source quality control, field quality control, and start-up of the system.
- f. Responsibility for correction period obligations for the PSCS.
- g. Training of operations and maintenance personnel in operation and maintenance (including calibration and troubleshooting) of the instrumentation and control system excluding the PLC, OIT, or HMI configuration.
- h. Handling of all warranty obligations for the PSCS components.

C. Related Sections (***\*\*\*Designer shall update the related sections list as needed\*\*\****):

1. Section 26 29 37, Low Voltage Combination Magnetic Motor Starters

## 1.2 REFERENCES

A. Standards referenced in this Section are:

1. IEEE 802.1 LAN/MAN Bridging & Management
2. IEEE 802.1X, Port Based Network Access Control.
3. IEEE 802.3, Standards Defining Physical Layer and Data Link Layer Media Access Control (MAC) Sublayer of Wired Ethernet
4. ISA 5.1, Instrumentation Symbols and Identification.
5. ISA 5.4, Instrument Loop Diagrams.
6. ISA 20, Specification Forms for Process Measurement & Control Instruments, Primary Elements & Control Valves.
7. ISO 8802-3, Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
8. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
9. NFPA 70 (NEC), Article 770, Optical Fiber Cables and Raceways.

10. NFPA 79, Electrical Standard for Industrial Machinery.
11. UL 50, Safety Enclosures for Electrical Equipment, Non-Environmental Considerations.
12. UL 508A, Industrial Control Panels.

### 1.3 QUALITY ASSURANCE

#### A. Qualifications:

1. I&C Subcontractor:
  - a. Acceptable I&C subcontracts shall be one of the following, No substitutions or exceptions:
    - 1) C.C. Controls – Location: West Palm Beach, Florida. Phone: 561-293-3975
    - 2) Champion Controls – Location: For Lauderdale, Florida. Phone: 954-318-3090
2. Manufacturer: Manufacturers of instrumentation and control equipment furnished under this Section shall be experienced producing similar equipment and shall have the following qualifications:
  - a. Shall manufacture instrumentation and control system components that are fully developed, field-proven, and of standardized designs.
  - b. Shall have system of traceability of manufactured unit through production and testing in accordance with ANSI/ASQ Z1.4.
  - c. Shall have guaranteed availability clause (99.99 percent, minimum for one year) for microprocessor-based components and appurtenances.
  - d. Shall have documented product safety policy relevant to products proposed for the Work.

#### B. Pre-Construction Conference

1. Comply with the requirements of Division 1, Project Meetings and the requirements listed below. \*\*\* ***Designer shall update requirements as needed*** \*\*\*.
2. Prepare items listed below for presentation at pre-construction conference. Submit information to ENGINEER two weeks prior to pre-construction conference.
  - a. List of materials and equipment required for PSCS, and brand and model proposed for each item.
  - b. List of proposed exceptions to the Contract Documents along with brief explanation of each.
  - c. General outline of types of tests to be performed to verify that all sensors and transducers, instruments, and digital processing equipment are functioning properly.
  - d. Submittal numbering, submittal protocol, and correspondence requirements.
  - e. Discussion of items listed under 1.4.B and C of this Section.

### 1.4 SUBMITTALS

#### A. Action Submittals: Submit the following:

1. Shop Drawings:
  - a. Field Instruments:
    - 1) Manufacturer's product name and complete model number of devices proposed for use, including manufacturer's name and address.
    - 2) Instrument tag number in accordance with the Contract Documents.
    - 3) Data sheets and manufacturer's catalog literature. Provide data sheets in accordance with ISA 20 and annotated for features proposed for use. For instruments not included in ISA 20, submit data sheets using a format similar to ISA 20.
    - 4) Description of construction features.
    - 5) Performance and operation data.
    - 6) Installation, mounting, and calibration details; instructions and recommendations.
    - 7) Service requirements.
    - 8) Range of each device and calibration information
    - 9) Descriptions of materials of construction and listing of NEMA ratings for equipment
  - b. Panels, Consoles, and Cabinets:
    - 1) Layout drawings that include:
      - a) Front, rear, and internal panel views to scale.
      - b) Tag number and functional name of components mounted in and on panel, console, or cabinet, as applicable.
      - c) Product information on panel components.
      - d) Nameplate location and legend including text, letter size and colors to be used.
      - e) Location of anchorage connections.
      - f) Location of external wiring and piping connections.
      - g) Mounting and installation details, coordinated with actual application.
      - h) Proposed layouts and sizes of operator interface graphic display panels.
      - i) Calculations for heating and cooling of panels
      - j) Subpanel layouts and mounting details for items located inside control panels.
    - 2) Product information on panel components including:
      - a) Manufacturer's product name and complete model number of devices being provided, including manufacturer's name and address.
      - b) Instrument tag number in accordance with the Contract Documents.
      - c) Data sheets and catalog literature. Submit data sheets as shown in ISA 20 and annotated for features proposed for use. For instruments not included in ISA 20, submit data sheets with format similar to ISA 20.
      - d) Description of construction features.
      - e) Performance and operation data.
      - f) Installation, mounting, and calibration details; instructions and

- recommendations.
- g) Service requirements.
  - 3) Wiring and piping diagrams, including the following:
    - a) Name of each panel, console, or cabinet.
    - b) Wire sizes and types.
    - c) Terminal strip and terminal numbers.
    - d) Wire color coding.
    - e) Functional name and manufacturer's designation for components to which wiring and piping are connected.
    - f) Lightning and surge protection grounding.
  - 4) Electrical control schematics in accordance with NFPA 79. Drawings shall be in accordance with convention indicated in Annex D of the NFPA 79. Typical wiring diagrams that do not accurately reflect actual wiring to be furnished are unacceptable. Tables or charts for describing wire numbers are unacceptable.
  - 5) Stock list or bill of materials for each panel including tag number, functional name, manufacturer's name, model number and quantity for components mounted in or on the panel or enclosure.
  - 6) Detail showing anchorage plan of wire bundles between subpanels and front panel mounted devices.
- c. Field wiring and piping diagrams, include the following:
- 1) Wire and pipe sizes and types.
  - 2) Terminal numbers at field devices and in panels.
  - 3) Fiber optic termination designations in the field and in panels.
  - 4) Color coding.
  - 5) Conduit numbers in which wiring will be located.
  - 6) Locations, functional names, and manufacturer's designations of items to which wiring or piping are connected.
- d. Pump Station Control System:
- 1) Hardware:
    - a) Layout drawings showing front, rear, end and plan views to scale of equipment, I/O components, power supplies, and peripheral devices.
    - b) Equipment ventilation requirements.
    - c) Interconnection diagrams, including termination details, cable identification list, and cable length.
    - d) Drawings showing equipment layout.
    - e) Installation requirements, instructions, and recommendations.
  - 2) Software:
    - a) Licensing agreement with name of licensee, renewal requirements, release and versions, expiration dates (if any) and upcoming releases scheduled before Project completion. When upcoming releases are expected, provide descriptions, when available, of features that differ from the proposed release.
  - 3) System I/O Loop Wiring Diagrams: Prepare Shop Drawings on channel-by-channel basis and include the following information:
    - a) Channel identification, module type (embedded or expansion) and slot number for expansion modules, and module terminal

point numbers. Include location and identification of intermediate panel and field terminal blocks and terminal numbers to which I/O wiring and power supply wiring is connected. Identify power supply circuits with designation numbers and ratings.

- b) Wiring types, wire numbers, and color coding.
- c) Designation of conduits in which field I/O wiring will be installed.
- d) Location, functional name, tag numbers and manufacturer's module numbers of panel and field devices and instruments to which I/O wiring will be connected.
- e) Prepare loop wiring diagrams in accordance with ISA 5.4.

- e. Complete point-to-point interconnection wiring diagrams of field wiring associated with the system. Diagrams shall include the following:
    - 1) Field wiring between each equipment item, panel, instruments, and other devices, and wiring to control stations, panelboards, and motor starters. Some of this equipment may be specified in other Divisions, CONTRACTOR is responsible for providing complete point-to-point interconnection wiring diagrams for control and monitoring of that equipment.
    - 2) Numbered terminal block and terminal identification for each wire termination.
    - 3) Identification of assigned wire numbers for interconnections. Assign each wire a unique number.
    - 4) Schedule showing the wiring numbers and the conduit number in which the numbered wire is installed.
    - 5) Junction and pull boxes through which wiring will be routed.
    - 6) Identification of equipment in accordance with the Contract Documents.
  2. Product Data:
    - a. Product data for field instruments in accordance with requirements for Shop Drawings in this Section.
    - b. Product data for panels, consoles, and cabinets in accordance with requirements for Shop Drawings in this Section.
    - c. Product data for field wiring provided for instrumentation and control service and not included under other Sections or contracts.
    - d. Product data for PSCS, including software and hardware.
  3. Samples:
    - a. Color charts for finish paint for panels. Provide full range of paint manufacturer's standard and custom colors. Color selection will be by ENGINEER.
    - b. Color charts for FRP panels. Provide full range of panel manufacturer's standard and custom colors. Color selection will be by ENGINEER.
  4. Factory Acceptance Test Procedure: Submit factory testing procedures that will be performed to fulfill requirements of the Contract Documents. Test procedure shall include the following:
    - a. Visual inspection of components and assembly.
    - b. Description of hardware operational testing.
    - c. Description of testing equipment to be used.
    - d. Sign-off sheets to be used at time of testing.
- B. Informational Submittals: Submit the following:
1. Documents to be submitted prior to pre-submittal conference, in accordance with Article 1.3 of this specification.
  2. Manufacturer's Instructions:
    - a. Shipping, handling, storage, installation, and start-up instructions.
  3. Source Quality Control Submittals:

- a. Factory test reports and results.
- 4. Special Procedure Submittals:
  - a. Submit notification to OWNER and ENGINEER at least 14 days before readiness to begin system checkout. Schedule system checkout on dates agreed to by OWNER and ENGINEER.
  - b. Submit written procedure for system checkout to ENGINEER three months prior to starting system checkout. Three months prior to starting system checkout submit written procedure for start-up to ENGINEER.
- 5. Field Quality Control Submittals:
  - a. Submit the following prior to commencing system checkout and start-up.
    - 1) Completed calibration sheets for each installed instrument showing five-point calibration (0, 25, 50, 75, 100 percent of span), signed by factory-authorized serviceman.
  - b. Field calibration reports
  - c. Field testing reports.
- 6. I&C Subcontractor's Reports:
  - a. Installation inspection and check-out report.
  - b. Submit written report of results of each visit to Site by Supplier's service technician, including purpose and time of visit, tasks performed, and results obtained. Submit within two days of completion of visit to the Site.
- 7. Qualifications Statements:
  - a. I&C Subcontractor
  - b. Manufacturer, when required by ENGINEER.
- C. Closeout Submittals: Submit the following:
  - 1. Operations and Maintenance Data:
    - a. Submit in accordance with Division 1, Operations, Maintenance and Warranty Manuals.
    - b. Include acceptable test reports, maintenance data and schedules, description of operation, wiring diagrams, and list of spare parts recommended for one year of operation with current price list.
  - 2. Record Documentation:
    - a. Prepare and submit record documents in accordance with Division 1, As-Built Documentation.
    - b. Revise all system Shop Drawing submittals to reflect as-built conditions in accordance with the following.
      - 1) Two copies of each revised Shop Drawings and documentation to replace outdated drawings and documentation contained in operation and maintenance manuals. Submit half-size black line drawings for each drawing larger than 11 inches by 17 inches. Include specific instructions for outdated drawing removal and replacement with record documents submittal.



- 2) Half-size black line prints of wiring diagrams applicable to each control panel shall be placed in clear plastic envelopes and stored in a suitable print pocket or container inside each control panel.
- 3) Submit CADD drawings of the point-to-point interconnection wiring diagrams updated to reflect final as-built equipment information and as-installed field installation information.

D. Maintenance Materials Submittals: Submit the following:

1. Spare Parts and Test Equipment
  - a. General
    - 1) For process sensors and other analog instruments, Supplier shall submit a separate quotation for recommended list of spare parts and test equipment. Separately list and price each item recommended. Spare parts quotation shall include a statement that prices quoted are valid for a period of one year from date of equipment installation and that Supplier understands that OWNER reserves the right to purchase none, any, or all parts quoted.

## 1.5 STORAGE AND HANDLING

- A. Prior to packaging, each manufacturer or Supplier shall securely attach tag number and instructions for proper field handling and installation to each instrument.
- B. Comply with Division 1, Materials and Equipment. \*\*\* *Designer shall update requirements as needed* \*\*\*.

## PART 2 – PRODUCTS

### 2.1 SYSTEM REQUIREMENTS

- A. Power Supplies:
  1. Electrically powered equipment and devices shall be suitable for operation on 115-volt plus-or-minus 10 percent, single-phase, 60 Hertz plus-or-minus two Hertz, power supply. If different voltage or closer regulation is required, provide suitable regulator or transformer at no additional cost to OWNER.
  2. Provide appropriate power supplies for field instruments requiring power source less than 115 volts. Power supplies shall be mounted in control panels or enclosures installed near associated instrument or in field panels.
  3. Power supplies shall be capable of minimum of 130 percent of maximum simultaneous current draw.
  4. Provide power on-off switch or air circuit breaker for each item provided under this Section that requires electric power.

- B. Signal Requirements:
1. Control system shall use 4 to 20 mA DC analog signals, unless otherwise shown or indicated.
  2. Provide signal converters and repeaters where required. Adequately size power supplies for signal converters and repeater loads.
  3. Analog signals shall be isolated from ground.
  4. Signals transient DC voltage shall not exceed 300 volts over one millisecond and shall not have a DC component over 300 volts.
  5. Discrete signals shall use 24 VDC.
- C. Surge Protection Requirements:
1. Provide surge protection to protect electronic instrumentation and control systems from surges propagating along signal and power supply cabling. Protection systems shall be such that the protection level shall not interfere with normal operation, but shall be lower than instrument surge withstand level, and be maintenance-free and self-restoring.
  2. All analog input signals shall be wired through a surge protector.
  3. Provide instruments in suitable metallic cases, properly grounded. Ground wires for surge protectors shall be connected to good earth ground and, where practical, run each ground wire individually and insulated from other wires. Mount protectors within instrument enclosure or in separate junction box compatible with the area designation coupled to the enclosure.
- D. Miscellaneous:
1. General:
    - a. Instrumentation components shall be heavy-duty types, constructed for continuous service.
    - b. System shall consist of equipment models currently in production.
    - c. Materials and equipment, including cabling and interconnections, shall be in accordance with Division 16, Electrical, and manufacturer's recommendations, unless indicated otherwise in the Contract Documents.
    - d. Materials and equipment shall, where applicable, be in accordance with UL standards and be so marked and labeled.
  2. Logic and control loops shall be fail-safe. Instrumentation components shall return automatically to accurate measurement within 15 seconds upon restoration of power after power failure and when transferred to standby power supply.
  3. Provide surge protection for instruments and other control system components that could be damaged by electrical surges. Provide lightning arresters on both ends of communication lines, except for fiber optic cabling, external to buildings or structures, including leased telephone lines and similar communication lines.
  4. Field-mounted instruments and system components shall be constructed for use in humid and corrosive service conditions. Field-mounted instrument enclosures, junction boxes and appurtenances shall have NEMA rating appropriate for hazardous rating requirements shown or indicated on

Electrical Drawings, instrument data sheets, and elsewhere in the Contract Documents.

5. Miscellaneous hardware such as fittings, fasteners, and screws, shall be Type 316 stainless steel or other appropriate material to prevent galvanic reactions, and shall be suitable for service intended. Piping stands shall be provided for fastening instruments as required. Provide threaded pipe stands with flange bolted to slab. Use carbon steel piping and flanges painted in accordance with Section 09 91 00, Painting. \*\*\* **Designer shall update requirements/reference as needed** \*\*\*.
6. Data processing equipment and relays with interconnections to field devices shall be wired through field wiring terminal blocks in the panel. Terminating field wiring directly to terminals on relay base is unacceptable.
7. Arrange panel-mounted instruments, switches, and other devices ergonomically for functional use and ease of maintenance. Similar types of panel-mounted devices shall be by one same manufacturer and of the same model line.
8. Equipment furnished shall be of modular construction and be capable of field expansion through installation of plug-in circuit cards and additional cabinets as necessary.
9. Field- and panel-mounted instruments shall be tagged with equipment number and nomenclature indicated in the Contract Documents; if not so indicated, tag in accordance with approved Shop Drawings.
10. Coordinate ranges and scales specified in the Contract Documents with manufacturer of the equipment actually furnished for operability over the intended range. Complete the coordination prior to submitting Shop Drawings to ENGINEER.
11. Treat field-mounted devices with anti-fungus spray.
12. Protect field-mounted devices from exposure to high and freezing temperatures to provide complete operability under the environmental conditions indicated in the Contract Documents.

E. Environmental Conditions:

1. Provide control system suitable for continuous operation under the following conditions:
  - a. Indoor Instruments:
    - 1) Ambient Temperature: Zero degrees F to 120 degrees F.
    - 2) Relative Humidity: 100 percent, maximum.
  - b. Outdoor Instruments
    - 1) Ambient Temperature: -15 degrees F to 120 degrees F.
    - 2) Relative Humidity: 100 percent, maximum.
2. Protect outdoor-mounted field instruments from direct sunlight by providing sunshade for instruments. Construct sunshade out of non-corrosive material. Sunshade shall withstand wind velocity of 130 miles per hour.

F. Spare Parts

1. General:
  - a. Furnish the spare parts as indicated below, identical to and interchangeable with similar equipment provided under this Section.

- b. Provide source quality control for spare parts as part of factory testing prior to shipment of instrumentation and control equipment.
- 2. Furnish the following PLC Spare Parts:
  - a. One spare PLC.
  - b. One spare analog input module.
  - c. One spare analog input/output combo module.
- 3. Furnish the following spare parts:
  - a. Five of each type of input/output relay for each quantity of forty or fraction thereof provided under the Contract.
  - b. One replacement power supply for each type and size provided under the Contract.
  - c. One spare din-rail mounted UPS.
  - d. One-year supply of all expendable or consumable materials.
  - e. One per quantity of ten or fraction thereof provided, per range of field instruments including insertion type instruments. No spares are required for inline instruments such as magnetic flow meters and flumes or venturis that include flow tubes through which flow is conveyed.
  - f. Twelve of each type and size of fuse used in instruments and in control panels.

## 2.2 PANELS

- A. General Provisions:
  - 1. Provide electrical components and devices, support hardware, fasteners, and interconnecting wiring and piping required to provide control panels complete and operational.
  - 2. Locate and provide hardware so that connections can be easily made and there is ample room for servicing each item.
  - 3. Prevent movement by adequately supporting and restraining devices and components mounted on or within panel.
  - 4. Provide panels with sub-panels for installation of all internally mounted hardware.
  - 5. Provide numbered terminal strips for terminating field wiring and wiring from other panels, unless otherwise shown or indicated.
  - 6. Provide copper grounding studs for hardware requiring grounding.
  - 7. Provide the following convenience accessories inside each panel:
    - a. One 120 vac, 20-amp duplex, grounding type receptacle.
    - b. One 120 vac fluorescent service light fixture with 20-watt lamp and protective plastic shield or appropriate wattage incandescent bulb for panels two feet by two feet and smaller.
    - c. One 120 vac snap switch, to turn on service light, mounted in outlet box with cover and located so that switch is easily accessible from access door.
    - d. Service light with switch and duplex receptacle shall have a dedicated circuit breaker.
  - 8. Control of Environment:
    - a. Provide 120 VAC thermostatically controlled fan-driven heater units to maintain stable temperature within enclosure to protect equipment from

- harmful effects of condensation, corrosion, and low temperatures inside panels.
- b. Provide automatically controlled closed-loop heat exchangers or closed-loop air conditioners to maintain temperature inside each enclosure at optimum operating temperature rating of components inside the enclosure.
  - c. Each heat exchanger or air conditioner shall have a dedicated, properly sized and -rated circuit breaker within the panel.
  - d. Submit supporting calculations as part of panel Shop Drawing submittal if panel equipment to comply with specified environmental requirements is proposed to be deleted as unnecessary.
  - e. The fan-driven heater unit, closed-loop heat exchangers or closed-loop air conditioners, duplex utility receptacle, and fluorescent service light shall have a one dedicated 120-volt ac service from the source, separate from the 120-volt service from the source for the process control hardware within the panel.
9. Panels to be located in non-hazardous (non-classified) environments shall comply with UL 50 and UL 508A.
  10. Panels to be located in hazardous (classified) environments shall comply with UL 698A and UL 2062.
  11. CONTRACTOR is responsible for detailed layout and design of panels, in accordance with the Contract Documents. Base cutouts and design on instrument manufacturers' requirements.
  12. For front-opening panels, install no device less than three feet above operating floor level, unless otherwise shown or indicated.
  13. Wire bundles between subpanels and front panel-mounted devices shall be anchored and protected from damage by opening and closing of panel door.
  14. Do not locate front panel-mounted devices requiring manipulation by operating personnel, such as pushbuttons, hand switches, controllers, and similar devices, higher than 5.5 feet above finished floor.
  15. Wire trays located on either side of terminal strips shall have minimum clearance of 1.5 inches between wire trays and terminal strip.
  16. Provide three-inch high channel base assembly, drilled to mate panel to floor pad.
  17. Provide easily accessible pocket built into panel door to enclose "as built" panel wiring diagrams.
  18. Panels shall be UL-listed.

B. Identification:

1. Provide laminated plastic nameplate for identification of panels. Use self-tapping stainless-steel screws for fastening nameplates to panels. When self-tapping screws may degrade panel's NEMA rating, retain NEMA rating intact by using gaskets on each side of panel surface and use retaining plate on the panel back that is same size as nameplate. When gaskets and retaining plate are used, use full-penetration screws with nuts.
2. Panel identification nameplates shall have 1/2-inch-high engraved letters.
3. Identify front panel-mounted devices with nameplates engraved with functional description of the device. Nameplate engraving shall be in

- accordance with the identification provided in the Drawings.
4. Tag electric components and devices mounted within panels with high adhesive labels.
  5. Identify terminal strips with nameplate engraved as “TB-XX” where “XX” is the numerical identification of terminal strip.
  6. Identify terminals within each terminal strip with sequential numbers and wire numbers.
  7. Internal panel wiring shall be color-coded and numerically identified with unique wire numbers affixed at each end of each wire. Color coding shall be in accordance with panel wiring color code table, below:

**Panel Wiring Color Code Table**

Description	Color
110 vac panel power before fuses or breakers	Black
Controlled 110 vac power (e.g., after relay contacts, selector switch contacts, and similar equipment.)	Red
110 vac power source from devices external to panel	Yellow
110 vac neutral	White
24 vdc positive power from power supplies	Brown
24 vdc negative power from power supplies	Manufacturer choice
Controlled 24 vdc power (e.g., after PLC output contacts, relay contacts, and similar)	Blue
24 vdc positive power from devices external to panel	Orange
24 vdc negative power from devices external to panel	Manufacturer choice
24 vdc four to 20 mA DC signal cable	Grey sheath with red positive, clear negative
Grounding wire	Green

**C. Panel Construction Features:**

1. Control panels located in non-environmentally controlled areas and outdoor areas shall be rated NEMA 4X and with the following features:
  - a. Panels shall be Type 316L stainless steel construction with minimum thickness of 12-gage for all surfaces, except areas requiring reinforcing, with a smooth-brushed finish.
  - b. Stainless steel screw clamp assemblies on three sides of each door.
  - c. Rolled lip around three sides of door and along top of enclosure opening.
  - d. Hasp and staple for padlocking.
  - e. Provide clear-plastic, gasketed lockable hinged door to encompass non-NEMA 4X front-of-panel devices.

**D. Electrical Systems:**

1. Power Source and Internal Power Distribution:
  - a. Provide in the panel, near where incoming power is terminated, nameplate with panel power supply source, type, voltage, and circuit number.
  - b. Protect incoming 120 vac power feeds to power the panel by providing lightning and surge arrestors, properly connected to grounds.
  - c. Provide panels with internal 120 vac power distribution system with

properly sized and -rated circuit breakers to distribute power. Power not more than three devices from a single breaker. When power supplies are included in the panel, not more than two power supplies shall be powered from a single breaker. The PLC shall have its own dedicated circuit breaker. Convenience receptacles and interior panel lights shall have their own breakers. When one or more field instruments require 120 VAC power from the panel, power not more than three instruments from a given breaker.

d. Provide space for a minimum of two spare breakers in each panel.

2. Wiring:

- a. Internal wiring shall be Type MTW and THW stranded copper wire with thermoplastic insulation rated for 600 volts at 85 degrees C for single conductors, color-coded and labeled with wire identification.
- b. For DC signal wiring, use shielded cable with 18-gage conductors. DC field signal wiring terminal strips shall be capable of handling wires up and including No. 12 size.
- c. For AC power wiring, use No. 12 minimum AWG. For AC signal and control wiring, use No. 16 minimum AWG. For wiring carrying more than 15 amps, use sizes required by the NEC (NFPA 70).
- d. Inside of panels, route DC signal wiring separately from power wiring with minimum separation distance of six inches.
- e. Use covered wire trays to route internal panel cables and wiring. wire trays in each section of panel shall be appropriately sized to accommodate the quantity of wires to be routed with a spare capacity of 40 percent.
- f. Install wire troughs inside panels along horizontal or vertical routes to present a neat appearance. Angled runs are unacceptable.
- g. Wiring that is routed without wire trays shall be adequately supported and restrained to prevent sagging or other movement. Use of adhesive anchors to support or restrain wiring is unacceptable.
- h. Terminate internal panel wiring using ferret tip, insulated, crimp-on connectors; soldered connectors are unacceptable. Provide panels with 600-volt rated barrier type terminal strips mounted on Din rails. Identify terminal strips as indicated in this Section. Identification devices shall be self-stick, plastic tape strips with permanent, machine- printed numbers.
- i. Terminal blocks for 4-20 mA signals shall be fused and knife disconnect type. Fused terminal blocks shall have LED blown fuse indication.
- j. Wiring in panels shall be installed such that, if wires are removed from any one device, power will not be disrupted to other devices.
- k. Provide spare terminals equal in number to 20 percent of terminals used for each type of wiring (e.g., DC signal and AC power).
- l. Provide ground terminals to terminate the shield wire of shielded cables. Termination of more than two shielded wires on a single ground terminal is unacceptable.
- m. Provide a single copper bus bar with 5/16-inch diameter copper grounding stud to connect the panel to external ground. Panel's internal grounds shall be terminated to the bus bar.

- n. Where wires pass through panel walls, provide suitable bushings to prevent cutting or abrading of insulation.
- o. When DC power or low voltage AC power is required, furnish and install in the panel required power supplies and transformers.
- p. Provide complete wiring diagram of “as-built” circuitry enclosed in transparent plastic.

## 2.3 DATA SHEETS –PRIMARY SENSORS AND FIELD INSTRUMENTS

### A. General:

- 1. Primary sensors and field instruments shall be in accordance with the “data sheets” included in Part 3 of this specification.

## 2.4 PANEL INSTRUMENTS AND DEVICES

### A. General: Do not fabricate, ship, or assemble instruments and devices in panels until required Shop Drawings and other submittals required for fabrication are approved or accepted as required.

### B. Uninterruptible Power System

- 1. General: Uninterruptible Power System (UPS) shall be furnished to provide a reliable source of uninterruptible power for PSCP with no break in AC output power during a complete or partial interruption of incoming line power. UPS shall include dry contact alarms. UPS shall be UL listed.
- 2. Description: Online dual track power conditioner and true (0 ms transfer time) uninterruptible power supply providing isolation, line regulation and conditioning. Switch mode power supply for uninterrupted power with 0.5 to 0.7 power factor and 2.7 to 3.5 crest factor.
- 3. Features:
  - a. Unit shall provide uninterrupted conditioned power, under fully loaded conditions, for 20 minutes. Unit shall be sized to accommodate power requirements for all equipment it is to power for the required length of time and shall provide ten percent spare output capacity at minimum.
  - b. UPS Mounting: Din-rail
  - c. Battery Type: External as shown on the panel drawings.
  - d. Lighting and Surge Protection: Inherent 2000: One spike attenuation.
  - e. Regulation: One to three percent load regulation with less than 2 pF effective coupling capacitance for line to load.
  - f. Output Waveform: Computer grade sine wave with three percent maximum single harmonic and five percent maximum total harmonic distortion.
  - g. Output Frequency: 60 Hz  $\pm$ 0.5 Hz.
  - h. Operating Temperature: 1°C to 40°C.
  - i. Relative Humidity: Five to 90 percent non-condensing.
  - j. Input Protection: Independent battery charger fuse and DC fuses.
  - k. Output Protection: Inherently current limited ferro-resonant transformer.
    - l. Power Input: 120 VAC. 60 Hz, single phase, +3 percent, -3 percent.
    - m. Power Output: 24 VDC, +3 percent, -3 percent.



4. Products:
    - a. Phoenix Contact.
    - b. Or Equal.
- C. Power Supplies
1. General: Single unit and multiple unit power supplies, located in remote terminal units and field panels as required.
  2. Single Unit Required Features:
    - a. Solid state circuitry.
    - b. Surface mounting.
    - c. Input Power: 120 VAC  $\pm$ 10 percent, 60 Hz.
    - d. Output Power: 24 VDC or as required.
    - e. Line/Load Regulation:  $\pm$ 0.005 percent.
    - f. Ripple: 0.25 mV RMS.
    - g. Polarity: Floating output.
    - h. Ambient Temperature: -20°C to +71°C.
    - i. Response Time: <20 $\mu$ S.
    - j. Overload Protection: Internal preset.
    - k. Include mounting brackets, fuse, and mating connector for AC power plug.
  3. Multiple Unit Required Features:
    - a. Solid state circuitry.
    - b. Standard 19-inch RETMA (EIA) rail mounting.
    - c. Input Power: 120 VAC  $\pm$ 10 percent, 60 Hz.
    - d. Output Power: 24 VDC or as required.
    - e. Polarity: Floating output.
    - f. Ambient Temperature: -20°C to +71°C.
    - g. Response Time: <20 $\mu$ S.
    - h. Include over-voltage protection, output current limiting protection, provisions for paralleling power supplies and front panel mounted indicating fuses.
    - i. If the power supplies are connected in parallel, provide isolation diodes in series with the positive lead of each of the parallel connected power supplies.
    - j. Connections:
      - 1) Twist-lock AC power connector.
      - 2) DC power terminal strip.
  4. Products and Manufacturers: Provide one of the following:
    - a. Phoenix Contact.
    - b. Or Equal.
- D. Main and Branch Circuit Breaker
1. General:
    - a. Circuit breakers shall be furnished and installed in control panels to provide automatically operated switch protection in an electrical circuit from damage caused by an overload or short circuit.

- b. Branch circuit breakers shall be approved for branch circuit applications in the United States.
2. Features:
    - a. Type: High Density Circuit Breaker.
    - b. Provide Single Pole 120/240V breakers within the control panels.
    - c. Rating: Provide breakers with proper amp rating to protect the circuit it serves. Normal operating load of each circuit shall be noted on the panel power distribution wiring drawing.
    - d. Insulation Resistance: 100M-ohm at 500VDC.
    - e. Terminal Type: Tubular screw with self-lifting box lug.
    - f. Push-to-set mechanism for circuit actuation.
    - g. Manual trip button.
    - h. DIN rail mounted.
    - i. Status on/off indicator lights.
    - j. Compliance: UL 1077 Listed, CSA C22.2 No. 235, EN/IEC 60934
  3. Products and Manufacturers: Provide one of the following:
    - a. Allen Bradley.
    - b. Or Equal.
- E. Selector Switches, Pushbuttons, and Indicating Lights
4. General:
    - a. Selector switches, pushbuttons and indicating lights shall be supplied by one manufacturer and be of the same series or model type.
    - b. Type: Heavy duty, oil tight.
    - c. Provide legend plate for indication of switch, pushbutton or light function (e.g., "OPEN-CLOSED", "HAND-OFF-AUTO").
    - d. Mounting: Flush mounted on control panel front, unless otherwise noted.
    - e. NEMA rated to match panel in which mounted.
  5. Selector Switches:
    - a. Type: Provide selector switches with number of positions as required to perform intended functions as shown and specified.
    - b. Contacts:
      - 1) Provide number and arrangement of contacts as required to perform intended functions specified, but not less than one single pole, double throw contact.
      - 2) Type: Double break, silver contacts with movable contact blade providing scrubbing action.
      - 3) Rating: Compatible with AC or DC current with devices simultaneously operated by the switch contacts, but not less than 10 A resistive at 120 VAC or DC continuous.
    - c. Switch Operator: Standard black knob.
  6. Pushbuttons (Standard or Illuminated):
    - a. Type: Provide momentary lighted and/or unlighted, single and/or dual type pushbuttons as required to perform intended functions specified and shown.
    - b. Contacts: Comply with the requirements specified for selector switches.

7. Indicating Lights:
  - a. Type: Light-Emitting Diode (LED).
  - b. Lamps: 2.2 volt, long life (20,000 hours minimum).
8. Button and Lens Colors:
  - a. Red for indication of open, on, or running.
  - b. Green for indication of closed, off (ready), or stopped.
  - c. Amber for indication of equipment malfunction, process trouble and alarms (e.g., "HIGH LEVEL", "LOW LEVEL", etc.).
  - d. White for indication of electrical control power on.
  - e. Blue for indication of remote.
9. Products and Manufacturers: Provide one of the following:
  - a. Eaton Corp.
  - b. Allen Bradley.
  - c. Or Equal.

F. Control Relay

1. Type: General purpose, plug-in type rated for continuous duty.
2. Construction Features:
  - a. Coil Voltages: 24 VDC or 120 VAC, as required.
  - b. Contacts:
    - 1) Silver cadmium oxide rated not less than 5 A resistive at 120 VAC or 24 VDC continuous.
    - 2) For switching low energy circuits (less than 200 mA) fine silver, gold flashed contacts rated not less than 3 A resistive at 120 VAC or 28 VDC continuous shall be provided.
  - c. Relays to have clear plastic dust cover.
  - d. Relays to have pilot light to show energized coil.
  - e. Relays to be UL recognized.
3. Products and Manufacturers: Provide one of the following:
  - a. Schneider Electric, Square D Company
  - b. Dayton
  - c. Or Equal.

G. Time Delay Relay

1. Type: Dial adjustable, plug-in type time delay relay providing delay-on-make, delay-on-break, or interval operation.
2. Construction Features:
  - a. Type: Dial adjustable, plug-in type time delay relay providing delay-on-make, delay-on-break, or interval operation.
  - b. Construction Features:
    - 1) MOS digital circuit with transformer coupled power.
    - 2) Switch selectable ranges for 1 second, 10 seconds, 1 minute, 10 minutes, 1 hour, and 10 hours.
  - c. Minimum Setting: Three percent of range, except 50 milliseconds for one-second range.
  - d. Setting Knob Accuracy: 10%
  - e. Contacts: SPDT rated for 5A at 24 VDC.
  - f. Housing: Plug-in design with dust and moisture resistant molded plastic

case.

- g. Power Input: 24 VDC
  - h. Operating Temperature: 0°C to 55°C.
  - i. The unit shall have an LED to show timing status.
  - j. Relays to be UL recognized.
3. Products and Manufacturers: Provide one of the following:
- a. Allen Bradley
  - b. Schneider Electric
  - c. Eaton
  - d. Or Equal

H. Programmable Logic Controller (PLC)

- 1. The PLC will be programmed by the OWNER assigned Programmer to perform functions shown and specified.
- 2. The PLC shall support Ladder Logic programming language as per IEC 61131-3. The ladder diagram format shall contain a complete cross reference with each coil referred to in logic and identified as normally open or normally closed.
- 3. The controller shall include embedded input, output, and communication capability and additionally support up to 7 expansion input and output modules.
- 4. A self-diagnostics package to determine proper processor operation shall be included. Diagnostic LED shall be provided in clear view on the front of the PLC.
- 5. Changing on-line control logic shall not necessitate halting of the processor.
- 6. Burn-in for all printed circuit boards and modules shall be performed at the factory.
- 7. Support PID control and arithmetic functions.
- 8. Memory: Non-volatile battery backed Random Access memory (RAM)
- 9. Operating Temperature: 0°F to 140°F.
- 10. Clock: Real time clock.
- 11. Input Power: 24 VDC
- 12. Embedded I/O:
  - a. Digital Input: Twenty (20) 24 VDC inputs
  - b. Digital Output: Six (6) relay outputs
  - c. Analog Output: Two (2) voltage outputs
- 13. Additional Modules:
  - a. Digital Input Module:
    - 1) Sixteen (16) Channels 24 VDC inputs
  - b. Current Input Module:
    - 1) 4-20 mA DC
    - 2) Four (4) Current Input Channels
  - c. 2 Current Input / Current Output Module
    - 1) 4-20 mA DC
    - 2) Two (2) Current Input Channels
    - 3) Two (2) Current Output Channels
- 14. Ethernet Interface Module:
  - a. Standard Ethernet media (10baseT, 100baseT, and fiber).

- b. RJ-45 interface.
  - c. Common Industrial Protocol (CIP) EtherNet/IP and DNP3 over IP protocols.
  - d. Subnet masking.
15. Programming Software: RSLogix 500, Professional Edition as manufactured by Allen Bradley. Provide latest version.
  16. Product and Manufacturer:
    - a. MicroLogix 1400 Series manufactured by Allen Bradley.
    - b. No Substitutions
- I. Operator Interface Terminal (OIT):
1. Provide a programmable Operator Interface Terminal (OIT) to enable Operator to control and monitor field equipment. The OIT unit shall be flush panel mounted on the front of the panel. OIT unit shall be provided with all necessary hardware, cables, and software to accomplish the interface as specified herein and shown on the Contract Drawings.
  2. Performance Requirements:
    - a. The OIT shall be designed to display directly connected to Ethernet network and shall be able to transfer up to twenty-two 64 word blocks each way.
    - b. The OIT shall be provided with off-line development software which allows development of graphic picture files, touch screen key files, alarm files, trend files, system configurations, variables, and screen definitions. Provision shall be made to store commonly used symbols and screen definitions. Software license shall be for an unlimited time for use on hardware provided as part of the Contract or their successors. All licenses shall be in the name of the OWNER and turned over to the OWNER on the conclusion of Contract.
  3. Each OIT shall be provided with the following minimum requirements:
    - a. Display: 9-inch Color touch screen.
    - b. Field replaceable Backlight.
    - c. Minimum Memory:
      - 1) Flash: 512MB
      - 2) RAM: 512MB
    - d. Communication: Ethernet TCP/IP communication port.
    - e. Input Voltage: 24 VDC
    - f. Hot-swappable secure digital (SD) card. One per unit.
    - g. Operating Temperature: 0 – 45 degrees Celsius.
    - h. Humidity: 5 - 90% without condensation.
    - i. Rating: NEMA 4X, UL-listed.
  4. Product and Manufacturer: Provide one of the following:
    - a. PanelView Plus 7 as manufactured by Allen Bradley with FactoryTalk View Software and license.
    - b. No Substitutions.
- J. Cellular Router:
1. Provide a Cellular Router to establish communication with central Water Treatment Plant. The router unit shall be din-rail mounted and provided with

all necessary hardware, cables, and software to accomplish the interface as specified herein and shown on the Contract Drawings.

2. Requirement Features:
  - a. 802.2 Link Layer Discovery Protocol (LLDP) authentication for Ethernet, and MAC Address / IP Filtering.
  - b. Built-in Copper Ports:
    - 1) Ethernet interface, Six (6) 10/100Base-T(X) in accordance with IEEE 802.3.
  - c. Management support:
    - 1) Web-based management.
    - 2) Simple Network Management Protocol (SNMP)
  - d. Routing Protocol: Standard routing, NAT, 1:1-NAT, port forwarding
  - e. Minimum VPN Capability:
    - 1) Remote Sites: IPSec with at least 10 concurrent tunnels.
    - 2) Water Treatment Plant: IPSec with at least 30 concurrent tunnels.
  - f. Memory Card: Provide 512MB SD flash memory card for program and configuration.
  - g. Power Supply: 24VDC redundant power input.
  - h. Mounting: Din-rail mounting.
  - i. Data rates:
    - 1) Downlink < LTE 150 Mbps
    - 2) Uplink < LTE 50 Mbps
  - j. Antenna(s): 2x2 MIMO
  - k. Cellular Connectivity:
    - 1) SIM-Based Auto-carrier selection for 4G LTE Cellular. Provide SIM card, startup services, and unlimited plan for first two months of service, after which the contract shall be transferred to the OWNER.
    - 2) Compatible with OWNER's preferred wireless cellular carrier.
  - l. Operating Temperature: -40 to 140 °F
3. Product and Manufacturer: Provide one of the following:
  - a. TC MGuard RS4000, 1010461 and 2988146, by Phoenix Contact
  - b. No Substitutions

K. Cellular Antenna:

1. General:
  - a. Provide high directional gain 2x2 MIMO signal boosting antennas for 2G/3G/4G/5G networks and ground impulse suppressors for each location.
  - b. Mount antenna as specified and as shown. Final installation details shall be determined by the Contractor based on field observations and radio survey results.
  - c. The antennas shall meet the following requirements:
2. Frequency Range:
  - a. Antenna 1: 698-960/1710-2700/3400-3800
  - b. Antenna 2: 698-960/1710-2700/3400-3800
3. Gain: 6-9 dBi
4. Impedance: 50 Ohms
5. Max input power rating: 20 watts
6. Connector Type: N-Female

7. Flexible Extensions: 12-inch, 2 x C529 Coax (double shielded RG58), captive type N female with neoprene housing or equivalent.
8. Mounting hardware: Clamps, standoff hardware as recommended by the antenna manufacturer for pole or wall mount as required by survey report.
9. Antenna mast: Provide as suitable for withstanding 105 mph wind and ½” radial ice loading.
10. Ground impulse suppressor: Provide with each antenna.
11. Product and Manufacturer: Provide one of the following:
  - a. Panarama Antennas
  - b. Parsec Technologies
  - c. Taoglas
  - d. Or equal

## 2.5 IDENTIFICATION

### A. ISA Identification

1. A = Analytical.
2. B = Burner, Combustion.
3. C = Cooling (Cooling Condenser).
4. D = Dissolved.
5. E = Voltage.
6. F = Flow.
7. G = Intrusion.
8. H = Hand.
9. I = Current.
10. J = Power.
11. K = Time.
12. L = Level.
13. M = Manual.
14. N = UNDEFINED.
15. O = Overload.
16. P = Pressure.
17. Q = Communication.
18. R = Reverse.
19. S = Speed, Frequency.
20. T = Temperature.
21. U = Universal (Common).
22. V = Vibration.
23. W = Torque (Weight or Force).
24. X = Critical (Emergency).
25. Y = Event, State or Presence.
26. Z = Position, Dimension.

### B. Function Identifier:

1. A = Alarm
2. B = UNDEFINED.
3. C = Control.
4. D = Differential.

5. E = Element.
6. F = Failure.
7. G = UNDEFINED.
8. H = High.
9. I = Indication.
10. J = UNDEFINED.
11. K = Factor.
12. L = Low.
13. M = Mode.
14. N = Normal.
15. O = Oxygen.
16. P = UNDEFINED.
17. Q = Quantity.
18. R = Rotation.
19. S = Switch.
20. T = Timer
21. U = UNDEFINED.
22. V = Slow (output)
23. W = Slow (input)
24. X = Selector Switch (input)

## 2.6 PROCESS CONTROL DESCRIPTIONS

- A. Process Control Descriptions provided below are the general description for hardwired relay logic, programming control logic in the PLC, and configuring the OIT and SCADA software.
  
- B. Typical Triplex and Duplex Pump Station Field Instrumentation:
  1. LIT-101: Non-contact Radar Level Transmitter. Installed in the Wet Well.
  2. FIT-101: Station Flowmeter installed on the Discharge Header.
  3. LSHH-101: Alarm Level Float switch
  4. LSH-101/LSLL-101: Backup Level Float switches for backup control for the pumps
  5. LSH-102: High Alarm Valve Vault
  6. PIT-101: Discharge Header Pressure Transmitter
  7. PIT-102: Potable Water Pressure Transmitter
  
- C. Duplex Pump Controls
  1. For each pump, PSCP shall be equipped with following panel mounted devices:
    - a. Auto/Manual selector switch
    - b. Start/Stop pushbuttons
    - c. Run, Fail, and Moisture indicating lights
  2. PSCP will interface with the motor starters housed in housed in a separate control panel.
  3. When the Auto/Manual selector switch on the PSCP is in the Manual position, the start/stop pushbuttons shall control the pump.
  4. When the Auto/Manual selector switch on the PSCP is in the Auto position, operation of the pumps under normal conditions shall be automatic by the PLC in the PSCP based on Wet Well level as sensed from non-contact Radar Level instrument (LIT-101). If the Wet Well level signal fails, the lift station shall automatically switch to the backup control function that uses two float switches installed in the Wet well. Pumps shall operate as follows:



- a. All operator setpoints shall be adjustable at the OIT on the PSCP and remotely from the HMI at the WTP.
- b. Pumps shall operate in a Lead/Lag configuration. The operator shall be able to select the Lead and Lag pumps manually or select “Auto Alternation” mode based on pump runtimes.
- c. The pump selected as Lead shall start when the level rises to an operator adjustable start setpoint.
  - i. The adjustable setpoint range for pump start shall be ###.##’ (EL. ##.##) to ###.##’ (EL. ##.##) measured from the bottom of the wet well.
  - ii. Use ###.##’ (EL. ##.##) for the initial startup Lead Pump Start Level Setpoint.
- d. The Lead Pump shall stop when the level drops to an operator adjustable stop setpoint.
  - i. The adjustable setpoint range for pump start shall be ###.##’ (EL. ##.##) to ###.##’ (EL. ##.##) measured from the bottom of the wet well.
  - ii. Use ###.##’ (EL. ##.##) for the initial startup Lead Pump Stop Level Setpoint.
- e. The pump selected as Lag shall start if level continues to rise and goes an operator adjustable start setpoint:
  - i. The adjustable setpoint range for pump start shall be ###.##’ (EL. ##.##) to ###.##’ (EL. ##.##) measured from the bottom of the wet well.
  - ii. Use ###.##’ (EL. ##.##) for the initial startup Lag Pump Start Level Setpoint.
- f. Additionally, if wet well level does not fall below the Lead Pump Stop setpoint (described in item 2 above) within an operator adjustable time (initially set at 10 minutes) after the Lead pump has started, the Lag pump shall start.
- g. When both pumps (Lead and Lag) are running and the wet well level drops below Lag pump off set point, both pumps shall shut down.
  - i. The adjustable setpoint range for pump start shall be ###.##’ (EL. ##.##) to ###.##’ (EL. ##.##) measured from the bottom of the wet well.
  - ii. Use ###.##’ (EL. ##.##) for the initial startup Lag Pump Start Level Setpoint.
- h. If the Lead pump fails to start or trips while running, the Lag pump shall start immediately and take the place of the Lead pump. A pump failure alarm shall be generated for the failed pump and displayed on the OIT and on the remote SCADA HMI.
- i. At any point, if the High wet well alarm is activated and none of the two (2) pumps have started within a set backup control timer (adjustable between 0 to 5 minutes at the timer control relay in the PSCP), backup control shall get activated and the PSCP relay logic shall then operate the pumps:
  - i. Pump 1 shall start immediately and continue to run till Low-Low wet well is not sensed by the level float.
  - ii. If Pump 1 fails to bring down the wet well level in a set amount of time (adjustable between 0 to 10 minutes at the timer control relay in the PSCP), Pump 2 shall start.
  - iii. Both pumps shall continue running until the level is brought down to Low-Low level as sensed by the level float.
- j. Backup control shall remain active until locally released by the operator from the PSCP control panel push button ‘Backup Control Release to PLC’. Once released, the PLC in PSCP panel shall resume operation of the station.

#### D. Triplex Pump Controls

5. For each pump, PSCP shall be equipped with following panel mounted devices:
  - a. Auto/Manual selector switch
  - b. Start/Stop pushbuttons
  - c. Run, Fail, and Moisture indicating lights
6. PSCP will interface with the motor starters housed in a separate control panel.

7. When the Auto/Manual selector switch on the PSCP is in the Manual position, the start/stop pushbuttons shall control the pump.
8. When the Auto/Manual selector switch on the PSCP is in the Auto position, operation of the pumps under normal conditions shall be automatic by the PLC in the PSCP based on Wet Well level as sensed from non-contact Radar Level instrument (LIT-101). If the Wet Well level signal fails, the lift station shall automatically switch to the backup control function that uses two float switches installed in the Wet well. Pumps shall operate as follows:
  - a. All operator setpoints shall be adjustable at the OIT on the PSCP and remotely from the HMI at the WTP.
  - b. Pumps shall operate in a Lead/Lag/Lag-Lag configuration. The operator shall be able to select the Lead, Lag, and Lag-Lag pumps manually or select "Auto Alternation" mode based on pump runtimes.
  - c. The pump selected as Lead shall start when the level rises to an operator adjustable start setpoint.
    - i. The adjustable setpoint range for pump start shall be ###.###' (EL. ##.##) to ###.###' (EL. ##.##) measured from the bottom of the wet well.
    - ii. Use ###.###' (EL. ##.##) for the initial startup Lead Pump Start Level Setpoint.
  - d. The Lead Pump shall stop when the level drops to an operator adjustable stop setpoint.
    - i. The adjustable setpoint range for pump start shall be ###.###' (EL. ##.##) to ###.###' (EL. ##.##) measured from the bottom of the wet well.
    - ii. Use ###.###' (EL. ##.##) for the initial startup Lead Pump Stop Level Setpoint.
  - e. The pump selected as Lag shall start if level continues to rise and goes an operator adjustable start setpoint:
    - i. The adjustable setpoint range for pump start shall be ###.###' (EL. ##.##) to ###.###' (EL. ##.##) measured from the bottom of the wet well.
    - ii. Use ###.###' (EL. ##.##) for the initial startup Lag Pump Start Level Setpoint.
  - f. Additionally, if wet well level does not fall below the Lead Pump Stop setpoint (described in item 2 above) within an operator adjustable time (initially set at 10 minutes) after the Lead pump has started, the Lag pump shall start.
  - g. When both pumps (Lead and Lag) are running and the wet well level drops below Lag pump off set point, both pumps shall shut down.
    - i. The adjustable setpoint range for pump start shall be ###.###' (EL. ##.##) to ###.###' (EL. ##.##) measured from the bottom of the wet well.
    - ii. Use ###.###' (EL. ##.##) for the initial startup Lag Pump Start Level Setpoint.
  - h. If the Lead or Lag pump fails to start or trips while running, the Lag-Lag pump shall start immediately and take the place of the failed pump. A pump failure alarm shall be generated for the failed pump and displayed on the OIT and on the remote SCADA HMI.
  - i. At any point, if the High wet well alarm is activated and none of the three (3) pumps have started within a set backup control timer (adjustable between 0 to 5 minutes at the timer control relay in the PSCP), backup control shall get activated and the PSCP relay logic shall then operate the pumps:
    - i. Pump 1 shall start immediately and continue to run till Low-Low wet well is not sensed by the level float.
    - ii. If Pump 1 fails to bring down the wet well level in a set amount of time (adjustable between 0 to 10 minutes at the timer control relay in the PSCP), Pump 2 shall start.
    - iii. If wet well level is pumped down to the Low-Low level is not sensed by the level float, both pumps shall stop. If both pumps 1 and 2 fail to bring down the wet well level in a set amount of time (adjustable between 0 to 10 minutes at the timer control relay in the PSCP), Pump 3 shall start.

- iv. All three (3) pumps shall continue running until the level is brought down to Low-Low level as sensed by the level float.
        - j. Backup control shall remain active until locally released by the operator from the PSCP control panel push button 'Backup Control Release to PLC'. Once released, the PLC in PSCP panel shall resume operation of the station.
- E. Common controls for Duplex and Triplex Pump
- 1. Monitoring:
    - a. Control Panel cabinet internal temperature with high-temperature alarm based on an operator adjustable setpoint.
    - b. UPS battery Level indication
  - 2. Interlocks and Alarms:
    - a. In any mode of operation if the following condition(s) occur, the pump shall shut down, and an alarm shall be generated:
      - 1) Pump Overload
    - b. In Auto mode of operation if the following condition(s) occur, the pump shall shut down, and an alarm shall be generated:
      - 1) Pump Moisture
    - b. Additionally, an alarm shall be generated at the local OIT and WTP HMI for the following conditions:
      - 1) Backup Control Activated
      - 2) High-High Wet Well Level Alarm
      - 3) High Wet Well Level
      - 4) Low-Low Wet Well Level
      - 5) Transient Voltage Surge Suppressor (TVSS) Alarm
      - 6) One of the 24V DC Source Failed Alarm
      - 7) Control Power Fail Alarm
      - 8) Grinder Malfunction
      - 9) Generator Fail (if applicable)
      - 10) ATS on Generator (if applicable)
      - 11) High Pressure (Force Main)
      - 12) Valve Vault High Level Alarm

## 2.7 SOURCE QUALITY CONTROL

- A. General:
  - 1. Factory Test:
    - a. Representatives of OWNER, OWNER assigned Programmer, and ENGINEER will witness factory test at testing facility during operational test of equipment, either for individual units or as an integrated system. Give minimum of 30 days' notice to ENGINEER prior to the proposed testing date so that arrangements for test witnessing can be made. Presence of OWNER and ENGINEER during testing does not relieve CONTRACTOR from complying with the Contract Documents and shall not imply acceptance of equipment. When factory tests have been successfully completed, a submit factory test report to ENGINEER.
  - 2. OWNER assigned Programmer will upload the PLC Program, OIT Configuration, and HMI Software prior to the start of the Factory Test.
  - 3. Factory test results will be acceptable when all components within tested

control panel or system being tested successfully operate and meet its intended function and are so certified by the testing entity.

4. Do not ship the equipment until obtaining ENGINEER's acceptance of factory test results.

B. Factory Inspection:

1. Inspect each panel, console, device, and cabinet before testing and before shipping. Inspection shall include, but not be limited to the following:
  - a. Verify all "Approved as Corrected" comments on Shop Drawings were implemented.
  - b. Verify presence of and accuracy of nameplates and tags.
  - c. Verify that wire sizes and color-coding comply with the Contract Documents.
  - d. Verify presence of terminal blocks, terminal block numbers, and required quantity of spares.
  - e. Verify annunciator window engravings and quantity of spare windows comply with the Contract Documents.
  - f. Verify proper wiring practices and grounding.
  - g. Verify enclosure flatness, finish, and color.
  - h. Verify anchoring of wire bundles between subpanels and front panel-mounted devices.
  - i. Verify presence of applicable items specified in this Section.
  - j. Check and verify software licenses for latest release and license types.

C. Panel Operational Testing:

1. Test all input/output components to verify that internal panel wiring is properly terminated at correct locations. Verify initial ranges and settings.
2. Test all system hardware and software to verify proper operation as stand-alone units. Test shall include, but not be limited to, the following:
  - a. Power distribution and breaker ratings to match approved Shop Drawings.
  - b. Power fail/restart tests.
  - c. Diagnostics checks.
  - d. Demonstrate that all specified equipment functional capabilities are working properly.
  - e. Check and verify process displays are in accordance with approved Shop Drawings.
3. Test components and devices requiring data transmission to verify that communication between such components is working properly. Verify communication by using the same media required for the completed system at the Site as indicated in the Contract Documents.
4. Test system performance using simulated inputs. Signal generators shall be appropriately sized and calibrated for full range of use and shall have a power source to accommodate not less than a full day of testing.
5. Simulation devices shall be of suitable quality to not mask control panel defects.

## PART 3 – EXECUTION

### 3.1 INSPECTION

- A. Examine conditions under which the Work will be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

### 3.2 INSTALLATION

- A. Environmental Requirements:
  - 1. Do not install instruments in areas where construction may cause instrument to be damaged, without providing adequate protection for said instrument.
- B. Installation of Instrumentation:
  - 1. Secure field-mounted instruments to stands or brackets in accordance with manufacturer's recommendations, approved or accepted (as applicable) submittals, and the Contract Documents.
  - 2. Locate sensors where shown on the Drawings. Confirm exact locations in the field with ENGINEER.
  - 3. Install all devices so that devices are readily accessible for service and do not cause potential hazards.
- C. Services and Operator Instructions:
  - 1. Provide repairs or replacement of defective materials, equipment or workmanship, including with respect to equipment, the services of factory-trained servicemen.
  - 2. In addition to the calibration required for check-out, provide two additional calibrations on all instruments. The first re-calibration shall be approximately six months after acceptance of the system, and the second shall be approximately eleven months after acceptance. As part of each calibration, provide two copies of the calibration sheets, a detailed list of deficiencies (should any be found), and a statement that the entire system is in proper operation and condition (except for the deficiencies noted) and shall be turned over to the OWNER.

### 3.3 FIELD QUALITY CONTROL

- A. Tests and Inspections: Field-verify calibration and performance of each instrument prior to start-up of the associated equipment, and document on a separate sheet for each.
  - 1. For each calibration certification sheet, include the following information:
    - a. Project name.
    - b. Tag number and description.
    - c. Manufacturer.
    - d. Model and serial number.
    - e. Date, time and person who performed calibration.
    - f. Calibration data to include.

- 1) Input, output, and error at 0, 25, 75, and 100 percent of span for analog instruments.
- 2) Switch setting, contact action and deadband, if applicable, for discrete elements.
- g. Space for comments.
- h. Signature and date.
- 2. System Check-Out and Start-Up Responsibilities:
  - a. CONTRACTOR shall retain the services of the I&C Subcontractor to supervise and/or perform check-out and start-up of all system components. As part of these services, the I&C Subcontractor shall include for those equipment items not manufactured by him the services of an authorized manufacturer's representative to check the equipment installation and place the equipment in operation. The manufacturer's representative shall be thoroughly knowledgeable about the installation, operation and maintenance of the equipment.
  - b. Check and approve the installation of all instrumentation and control system components and all cable and wiring connections between the various system components prior to placing the various processes and equipment into operation.
  - c. Conduct a complete system checkout and adjustment, including calibration of all instruments, tuning of control loops, and checking operation functions. When there are future operational functions included in the Work, they should be included in the system checkout. All problems encountered shall be promptly corrected to prevent any delays in start-up of the various unit processes.
  - d. CONTRACTOR shall provide all test equipment necessary to perform the testing during system checkout and start-up.
  - e. CONTRACTOR shall furnish to the ENGINEER certified calibration reports for field instruments and panel mounted devices specified in this Section as soon as calibration is completed.
  - f. CONTRACTOR shall furnish ENGINEER an Installation Inspection Report certifying that all equipment has been installed correctly and is operating properly. The report shall be signed by authorized representatives of both CONTRACTOR and the I&C Subcontractor.
  - g. Instrumentation and Control System Field Test:
    - 1) Following demonstration of all system functions, the instrumentation and control system, including field sensors/transducers and instruments, and telemetry system shall be running and fully operational for a continuous 48 hour period.

### 3.4 MANUFACTURER'S SERVICES

#### A. General:

- 1. CONTRACTOR shall retain the services of the I&C Subcontractor to provide operation and maintenance training for all instrumentation and control system equipment as specified herein.
- 2. For equipment items not manufactured by the I&C Subcontractor, he shall provide for on-Site training by an authorized representative of the equipment

manufacturer as part of his services. The manufacturer's representative shall be fully knowledgeable in the operation and maintenance of the equipment.

3. CONTRACTOR shall be responsible for all costs associated with training and shall provide all required materials, texts and required supplies.
4. Training shall conform to the requirements of Division 1, Equipment Demonstration / Instruction.

B. On-Site Training:

1. General:

- a. Provide on-site operation and maintenance training by I&C Subcontractor and the equipment manufacturer representatives prior to placing the equipment in continuous operation.
- b. Training courses shall include time for students to develop and demonstrate understanding of training concepts. Testing shall include hands on training with equipment.
- c. At the conclusion of each course students shall be tested on course material. Testing shall include exercises where students must demonstrate proper response to normal operational needs, emergencies, and maintenance tasks. Every student shall be tested individually.
- d. Training shall accomplish the following:
  - 1) Provide instruction covering use and operation of the equipment to perform the intended functions.
  - 2) Provide instruction covering procedures for routine, preventive and troubleshooting maintenance, including equipment calibration.
  - 3) Explain procedures for placing the equipment in and out of operation and explain necessary actions and precautions to be taken regarding the overall plant monitoring and control system.
  - 4) Provide classes and field training as to how to change process control and alarm set points in all microprocessors based controllers and transmitters. Maintenance personnel shall be trained to enter passwords, programming, or configuration data, etc.

### 3.5 SUPPLEMENTS

- A. The supplements listed below, following the “End of Section” designation, are part of this Specification section.
- B. Data Sheets – Primary Sensors and Field Instruments
- C. I/O List

++ END OF SECTION ++

**DATA SHEETS - PRIMARY SENSORS AND FIELD INSTRUMENTS**

<b>PRODUCT</b>	<b>Flow Meter - Magnetic Flow Tube</b>		SHEET	1	OF	1
<b>PROJECT</b>	REMOTE SITES SYSTEM SCADA UPGRADE		SPEC. NO.	40 60 05 - 3.5 B.29	ADDENDUM/C.O.	
<b>TAG NO.</b>	<b>FE / FIT - 101</b>					
Ref. Dwg. No.:	1					
<b>PROCESS</b>						
Location:	2	TBD				
Service:	3	Lift Stations				
Vessel / Line No.:	4	TBD				
Fluid:	5	Raw Wastewater				
Temp. Min/Max:	6	60 to 90 degree F				
Flow Min/Max:	7	2.5-TBD gpm				
<b>PERFORMANCE</b>						
Range:	8	2.5-1500 gpm				
Accuracy:	9	±0.5% of flow rate over 1-31 fps range; ±0.005 fps for flows below 1 fps.				
Temperature:	10	0 to 140 degrees F.				
Repeatability:	11	±0.2% of range.				
Fluid Conductivity:	12	Minimum Limit: 5 µS/cm.				
Impedance:	13	Minimum Pre-amp Input: 1012 ohms.				
Drift:	14	Complete zero stability.				
<b>FLOW TUBE</b>						
Type:	15	Lined Metal Flow Tube.				
Element:	16	Conical or Elliptical Shaped Electrode.				
Electrode/Liner:	17	Refer to Materials Compatibility Chart.				
Line Size:	18	TBD				
Enclosure/Housing:	19	Die-cast, Low-copper Aluminum Alloy; Submersible in 30 feet water for 48 hours; Epoxy paint finish.				
Mounting:	19	Flange End Connections.				
ANSI Class:	20	TBD				
Additional Features:	21	316 S.S. Grounding Rings/Straps.				
<b>TRANSMITTER</b>						
Type:	22	Pulsed DC Magnetic Flow Transmitter.				
Output:	23	4-20 mA DC HART				
Power Supply:	24	120 VAC ±10%, 60 Hz ±3 Hz.				
Indication / Display:	25	Local LCD; Display Flow in Engineering Units; Provide Totalizer (See Notes, Line 39).				
Enclosure/Housing:	26	TBD; Solid state construction.				
Mounting:	27	Integrated with sensor mount; 316 S.S. hardware.				
Connections:	28	Electrical Conn.: 3/4 inch NPT.				
Commun. Cable:	29	Shielded Cable to flow tube.				
Area Classification:	30	Not Applicable				
Additional Features:	31	Automatic zeroing.				
<b>NOTES</b>						
Function:	32	System shall monitor liquid flows, display monitored flow value, and output a signal proportional to monitored flow.				
Installation:	33	Refer to Contract Drawing Installation Details and manufacturer's recommendations for installation.				
Calibration:	34	Provide ISO Factory Calibration Certificate. Provide one calibrator suitable to calibrate all flow tubes provided.				
Accuracy:	35	Accuracy shall be: - Unaffected by changes in fluid velocity, density, pressure, temp. or conductivity (above min. conductivity limits). - Verified by flow test curves. Submit flow test curves for furnished meters with a minimum of 10 equally spaced flow points, using water and a weight or volume tank. A "master meter" used as a reference standard is not acceptable. A test setup shall be submitted and approved prior to testing.				
Span Adjustment:	36	Unit shall have pre-calibrated continuous span adjustment over entire range. Provide direct reading thumbwheel switch or potentiometer for 1-31 ft/sec.				
Signal Conditioning:	37	Adjustable signal conditioning damping circuit with response times of 1-25 seconds minimum.				
Low Flow Cutoff:	38	Automatic low flow cutoff circuitry shall stop pulse output and local totalization when flow drops below 0.5% ±0.2% of calibrated upper range value.				
Totalizer:	39	Totalizer shall be: - 7-digit electromechanical or 8-digit electronic LCD unit, with reset and lithium battery backup. - Driven by high accuracy, field adjustable scaled pulse output (0.1-10 Hz or greater). - Integral with transmitter and visible through viewing window, or externally mounted adjacent to transmitter in a separate NEMA 4X enclosure or conduit with viewing window.				
Spool Piece:	40	None				
	41	Include a weather protection cover for the transmitter				
<b>MANUFACTURE</b>						
Manufacturer:	42	Provide the following: Endress & Hauser 0xDN Full Bore Promaq 400				