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SPECIFICATIONS - DETAILED PROVISIONS
Section 17010 - Programmable Logic Controller

C O N T E N T S

SECTION 17010
PROGRAMMABLE LOGIC CONTROLLER

PART 1 - GENERAL

1.01   DESCRIPTION

A.   This section specifies the requirements for a programmable logic controller (PLC) provided to monitor and control process conditions for an equipment system, including packaged equipment systems. The PLC shall be supplied by the Instrumentation and Control Subcontractor (ICS) or the manufacturer of the packaged equipment system. The requirements of the individual equipment system are equally applicable to the work specified herein. Where conflict exists, the individual equipment system sections shall take precedence.

B.   The equipment system PLC shall interface with the Plant and/or District Supervisory Control and Data Acquisition (SCADA) system, and shall include all components required for a complete, fully functional and operable process monitoring and control system.

C.   The PLC shall include all required enclosures, chassis, power supplies, central processing units, input/output (I/O) systems, communication systems, interfaces, instruments, devices, wiring, and terminations, as specified herein and as shown on the Drawings.

D.   PLC components specified herein shall be provided, as well as any ancillary or incidental equipment or devices, whether identified or not, that are required to support the monitoring and control of the equipment system and permit full use of the process equipment's capabilities.

1.02   RELATED SECTIONS

A.   The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.

B.   Related Specification Sections include, but are not limited to, the following:

1.   Sections of the Specifications specifying equipment systems controlled by PLCs.

2.   Division 16 – Electrical

3.   Division 17 – Instrumentation and Controls

1.03   REFERENCE STANDARDS AND CODES

All materials and equipment specified herein, including installation of same, shall conform to or exceed the applicable requirements of the following standards and codes (latest edition) to the extent that the provisions thereof are not in conflict with other provisions of these Specifications.

A.   International Society of Automation (ISA)

1.   ISA S5.1 – Instrumentation Symbols and Identification

2.   ISA S5.3 – Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems

3.   ISA S5.4 – Instrument Loop Diagrams

B.   National Electrical Manufacturers Association (NEMA)

1.   NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)

2.   NEMA ICS 6 – Industrial Control and Systems: Enclosures

C.   National Fire Protection Agency (NFPA)

1.   NFPA 70 - National Electrical Code (NEC)

2.   NFPA 79 – Electrical Standard for Industrial Machinery

D.   Underwriters Laboratories (UL)

1.   UL 508A – Standard for Industrial Control Panels

2.   UL 698A – Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations

1.04   DEFINITIONS

The following definitions are used throughout this Section:

A.   AI: Analog Input

B.   AO: Analog Output

C.   CPU: Central Processing Unit

D.   DI: Digital Input

E.   DO: Digital Output

F.   EEPROM: Electrically erasable programmable read-only memory

G.   HMI: Human-Machine Interface

H.   I/O: Input and/or Output

I.   LAN: Local Area Network

J.   Peer to Peer: Communication between two or more devices, typically PLCs, in which each device can control the data exchange.

K.   PID: Control action, proportional plus integral plus derivative.

L.   PLC: Programmable Logic Controller

M.   RAM: Random Access Memory

N.   Remote I/O: Any and all I/O that is located remotely from the processor.

O.   SCADA: Supervisory Control and Data Acquisition

P.   TCP/IP: Transmission Control Protocol and Internet Protocol

Q.   UPS: Uninterruptible Power Supply

1.05   SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A.   Shop Drawings

Contractor shall prepare and submit complete and organized information, technical data, and drawings for all equipment and components. All drawings shall be legible and reduced to a maximum size of 11" x 17" for inclusion within the submittal. Shop drawings shall include, but not be limited to, the following:

1.   Detailed Bill of Materials for all PLC panel hardware, and associated materials and components, listing: manufacturer's name, quantity, description, size, and catalog/part number.

2.   Complete documentation for all PLC panel hardware and associated components (i.e. PLC chassis backplane, CPU, power supply, I/O modules, communication modules, HMI, UPS, enclosure, relays, terminal blocks, etc.), including: manufacturer's product literature, specifications, performance capabilities, features and accessories, dimensions and weights, illustrations, and data in sufficient detail to demonstrate compliance with Specification requirements. Manufacturer's literature and data shall be marked to clearly delineate all applicable information and crossing out all inapplicable information.

3.   PLC block diagram showing all PLC components, HMI, and all communication interfaces, including Ethernet and serial communications to all equipment, devices, and SCADA.

4.   PLC control logic documentation in hard copy format, including a logic diagram and a control strategy in written, well organized sections using easy to understand narrative text explaining all input and output parameters, and all monitoring, control, and alarming functions. Provide a list of all addresses referenced in the logic diagram with a description of data associated with each address.

5.   Complete PLC I/O lists with I/O description, tags, addresses, and field terminal numbers.

6.   Where applicable, provide addressing for all communication network nodes using an Ethernet network connection.   Coordinate Ethernet TCP/IP addressing with the District.

7.   Hard copy documentation for HMI screens, including color prints of all proposed screen displays, written descriptions for each screen display parameter and input function.

8. PLC panel hardware arrangement drawings (plan view, and interior and exterior elevation views) with all hardware and components clearly shown, dimensioned, and labeled. Drawings shall show the equipment assembly, space requirements, clearances, and locations for conduits and anchor bolts.

9. Nameplate data including the nameplate material, heights of letter and inscriptions.

10. Control ladder diagrams for all hard wired control, protection, and monitoring circuits. Ladder diagrams shall show all switches, lights, pushbuttons, relays, etc., and shall be labeled with all associated wiring and termination numbers.

11. PLC panel wiring schematics. Wiring schematics shall show all interconnections between power sources, PLC, HMI, and all panel devices and components, and shall show all wiring numbers and termination numbers.

12. Loop diagrams for each monitoring and/or control loop. The loop diagrams shall show all components of the loop: analog and discrete I/O with reference to each PLC module I/O point, field instruments and components, and local switches, relays, signal isolators, etc., which are being provided for proper monitoring, control and operation. Loop diagrams shall be provided for all PLC I/O and all control system components, including those components specified in other Sections of these Specifications and/or shown on the Drawings. Loop diagrams shall be prepared according to ISA-S5.4 format, and shall also include the following:

   a. All interconnecting wiring between equipment, field instruments and devices, local control panels (if applicable), and PLC panel. Show all panel terminal block identification numbers and all wire numbers. Show all intermediate terminations between field elements and panels.

   b. The location of all equipment, instruments, and devices.

   c. The instrument/device description, including type, manufacturer, model number, range, set points, and operation (e.g. fail open, open on energization, normally closed, etc.) as applicable.

   d. The instrument/device loop power requirements back to the termination on the terminal block, fuse block (including fuse size), etc., as applicable.

e.   All grounding points within panels and cabinets, and identify the connection point of individual components.

f.   Each diagram with an instrument shall include a summary table with output capability of each transmitting instrument, input impedance of each receiving instrument, estimate of loop wiring impedance based on wire size and approximate length, total loop impedance, and reserve output capacity.

13.   Spare parts list as specified in this Section.

14.   Test procedures for factory testing and field testing required by Section 16950.

B.   <u>Operation and Maintenance Manual</u>

Contractor shall submit a detailed Operation and Maintenance (O&M) Manual for all PLC equipment and components specified herein. The O&M Manual shall be provided in accordance with the requirements of the District's General Conditions, Specification Section 01430, and as specified herein.

The O&M Manual shall include, but not be limited to, the following:

1.   PLC Performance Data and Drawings

a.   Detailed Bill of Materials for all PLC equipment and components, listing: manufacturer's name, quantity, description, size, range, and model/part number.

b.   Manufacturer's product literature, specifications, performance capabilities, features and accessories, and illustrations.

c.   Manufacturer's data and drawings showing dimensions, physical configurations, installation and mounting details, and wiring schematics.

d.   Control ladder diagrams for all hard wired control, protection, and monitoring circuits. PLC panel wiring schematics. Loop diagrams for each monitoring and/or control loop.

2.   PLC Installation and Operation Requirements

a.   Complete, detailed installation and operation instructions for all PLC equipment and components.

3.   PLC Programming Software and Licenses

     a.   Complete and detailed user manuals for all PLC and HMI programming software packages.

     b.   Software licenses issued to the District for all programming software packages. Software licenses originally assigned to others and transferred to the District will not be acceptable. Unless specified otherwise, two (2) complete licenses shall be provided for programming software packages for use on general purpose laptop computers with Windows 10 (or latest) operating systems.

     c.   A hardcopy printout and Flash Drive of all PLC and HMI programming and configuration files.

4.   PLC Service and Maintenance Data

     a.   Service and maintenance data shall include all information and instructions required by District's personnel to keep the PLC and all associated components functioning properly under the full range of operating conditions.

     b.   Explanation with illustrations as necessary for each service and maintenance task.

     c.   Recommended schedule of service and maintenance tasks.

     d.   Troubleshooting instructions.

     e.   List of maintenance tools and equipment.

     f.   Recommended spare parts list.

     g.   Names, addresses and phone numbers of all manufacturers and manufacturer's local service representatives.

5.   Manufacturer Warranties

C.   Final O&M Manual

Upon successful completion of startup and initial operation, Contractor shall submit a Final O&M Manual in accordance with the requirements of the District's General Conditions, Specification Section 01430, and as specified herein. In addition to the O&M Manual requirements specified above, the Final O&M Manual shall be supplemented with the following:

1.   As-built drawings (including all field changes) for all wiring and loop diagrams shall be incorporated into the Final O&M Manuals.

2.   A hardcopy printout and Flash Drive of all final PLC and HMI programming and configuration files (including all field changes).

1.06   DESIGN REQUIREMENTS

A.   Environmental

The PLC, including all associated components, shall be of industrial grade capable of operating continuously and satisfactorily in harsh environments. The PLC shall meet or exceed the following environmental requirements:

1.   Operating temperature: 0 to 55ºC (+32 to +131ºF)

2.   Storage temperature: -25 to 70ºC (-13 to 158ºF)

3.   Relative humidity: 30 to 95% non-condensing

4.   Altitude: 0 to 6,500 feet

5.   Degree of protection: NEMA 4X

6.   Shock resistance: $147m/s^2$ for 11ms

7.   Vibration resistance shall be in compliance with IEC 60068 and 61131.

The complete PLC shall be guaranteed to operate satisfactorily within the specified NEMA rated enclosure in ambient temperatures ranging from +32 to +110ºF.

B.   General Functions

As a minimum, the PLC system shall be designed to perform the following functions:

1.   Provide fully automated control of equipment system operation, including monitoring process conditions, providing control feedback, optimizing process performance, and interfacing with other Plant PLCs and/or the District SCADA system, as shown on the Drawings and as specified in individual equipment system sections and herein.

2.   Where specified, provide manual override of the automated controls via the HMI. Unless specified otherwise, critical system monitoring, alarm, and safety shutdown functions shall remain in effect.

3.   Unless specified otherwise, hold all system alarms locally until manually reset from the PLC HMI or from the SCADA system.

4.   Communicate with the SCADA system, which shall provide supervisory control of the equipment system operation via an Ethernet communication link.

5.   Provide control capabilities to restart the equipment system, including associated equipment, as required after a Plant shutdown or power failure in coordination with and as commanded by the SCADA system.

C.   General Performance Capabilities and Features

As a minimum, the PLC system shall be provided with the following performance capabilities and features:

1.   The PLC shall be capable of handling analog inputs/outputs (4-20ma); and discrete inputs/outputs (contact closures, pulses; momentary or latch operation) in addition to power monitoring.

2.   Input/output modules shall be furnished to accommodate all process monitoring and control specified in the equipment system specifications and shown on the Drawings plus any additional modules not shown, but essential to controlling and monitoring the system, providing a complete and final product.

3. All control programs shall reside in the PLC. All monitoring and control functions specified in the equipment system specifications and control loops/logic diagrams shown on the Drawings, and any additional controls necessary for operation of the system, shall be supplied and implemented by the equipment system manufacturer.

4. The PLC shall incorporate pre-programmed self-diagnostic software routines for maintenance.

5. The PLC shall incorporate a watchdog function to monitor: internal CPU failure, CPU memory failure, loss of communication between CPU and I/O modules, and CPU failure to execute logic program.

6. Unless specified otherwise, activation of alarms and stopping of equipment shall result from de-energization of control circuits, rather than energization of control circuits.

7. Unless specified otherwise, PLC failure mode shall be designed such that the loss of PLC supply power or output control signals to the equipment shall result in the equipment shutting down or operating in a predetermined safe mode.

8. PLC logic system failure shall not preclude proper operator intervention.

9. Unless specified otherwise, safety shutdown of equipment or equipment system shall require manual operator intervention via PLC HMI prior to reestablishing operation of the equipment or system.

10. Internal PLC system status and faults shall be monitored and displayed on the HMI. As a minimum, monitored items shall include:

    a. Power-up diagnostic (self-test) - passed/failed.

    b. Memory - OK/loss of memory.

    c. CPU - OK/fault

    d. Program run status – OK/fault

    e. Scan time - OK/overrun.

    f. Battery status – OK/low

    As a minimum, each monitored item shall be displayed on the HMI on a single PLC system status screen.

11.   PLC and HMI programming and configuration shall incorporate the following general strategies and functions:

a.   All calculations, analog value trip points, timers, etc. shall be accomplished in the PLC and not in the HMI.

b.   All analog inputs to the PLC shall be configured in the HMI software for historical trending.

c.   All set points for minimum and maximum values of analog outputs shall be operator adjustable via the HMI software.

d.   All set points for minimum and maximum values of analog inputs for process monitoring/control shall be operator adjustable via the HMI software.

e.   All open/close automatic valves and remote start/stop motors controlled by the PLC system shall have an adjustable maximum time value allowed to either open/close or start/stop. Failure to achieve the control function within this maximum time value shall result in a time out alarm for each piece of equipment. An alarm shall be generated from the PLC to the HMI for indication of the control function time out failure (e.g. Pump XXX Fail to Start, Valve XXX Fail to Open).

f.   The status of all alarms shall be latched until manually acknowledged via the HMI.

g.   HMI entries by the operator, such as set points and operation modes, shall be displayed on the process screens for information.

12.   Prevent unauthorized access to PLC and HMI programs and configurations with password-based security in the PLC and HMI software.

13.   The PLC system shall be designed with high noise immunity to prevent occurrence of false logic signals resulting from switching transients, relay and circuit breaker noise, or conducted and radiated radio frequency interference. Incorporate noise suppression and inductive load suppression design into PLC input, output, and logic modules.

14.   At a minimum, the PLC system shall be capable of using Ethernet/IP, Modbus, and OPC as communication protocols to communicate with other PLCs on the network and Plant SCADA or District SCADA, as applicable.

15. All PLC components such as PLC power supply, I/O modules, CPU, communication modules, backplane, wiring harnesses, etc. shall be provided with conformal coatings for protection against moisture and chemical contaminants.

16. All PLC component connections shall be screw-in type. Plug-in type connections will not be acceptable. All terminal blocks shall be screw-in type and shall provide a location for identifying associated terminal numbers.

17. Independent line fuses or circuit breakers shall be provided, per the manufacturer's recommendation, for each power supply, input module, output module, and other modules with separately derived power requirements.

18. All communication signals and 4-20 mA signals shall be properly conditioned for the PLC and protected from all sources of radiated energy or harmonics.

D. Appurtenances

1. The PLC processor, I/O modules, power supplies, and communication modules shall be provided as a complete system, as specified in the equipment system specification section and herein, and as shown on the Drawings. The PLC shall include all necessary components and hardware for a complete and fully functional system.

2. All special chassis or panel mounted power supplies, special interconnecting and programming cables, special grounding hardware, or isolation devices shall be furnished as required for proper operation of the equipment.

3. Signal converters, signal boosters, amplifiers, special power supplies, intrinsically safe relays and current repeaters, surge suppression devices, and isolation devices shall be furnished and installed as required for proper operation of the equipment.

E. Fabrication, Installation, and Testing

1. In addition to the design, fabrication, delivery, installation, and testing requirements specified herein, the PLC panel shall comply with all applicable requirements in Section 16950 - Custom Control Panels.

2. Equipment and components shall be Underwriters Laboratory (UL) listed for the purpose or UL recognized.

3.	The assembled PLC panel and individual components shall be UL listed and labeled. The assembled panel shall have a factory applied UL 508A label.

4.	Where applicable, intrinsic safety barriers within the PLC panel shall be provided per UL 698A with factory applied labels as required by UL.

5.	The PLC system shall be factory tested prior to delivery per Specification Section 16950.

**1.07	INSTALLED-SPARE REQUIREMENTS**

A.	Each PLC shall be provided with the following spare capacities.

1.	I/O points – 20 percent spare I/O capacity for each type of I/O signal required. All spare I/O shall be wired to the field terminal blocks.

2.	PLC chassis and backplane – the greater of:

a.	20 percent spare capacity, or

b.	3 spare backplane slots.

All spare backplane slots shall be equipped with slot filler modules.

3.	PLC memory – 50 percent spare program volatile memory capacity after all required programming is in place and operating. Executive or "housekeeping" programs shall not be counted in memory size rating.

4.	Field terminal blocks – 10 percent spare terminal blocks for each type of I/O signal required. These spare terminal blocks shall be in addition to the wired terminal blocks required for spare I/O capacity.

**1.08	SPARE PARTS**

A.	Each PLC shall be provided with the following spare parts. Spare parts shall be packaged for long term storage and identified with labels describing contents.

1.	I/O Modules: provide a spare of each type of module installed.

2.	CPU: provide a spare for each type of CPU installed.

3.	PLC Power Supplies: provide a spare for each type of power supply installed.

4.   Memory Cards: provide a spare for each type of memory card installed.

5.   Communication Module: provide a spare for each type of communication module installed.

B.   Provide manufacturer's recommended special tools for the PLC and associated components. Special tools shall include, but not be limited to: module installation/removal tools, terminal block installation/removal tools, reset tools, and drivers for special fasteners and screws.

1.09   MANUFACTURER SERVICES AND COORDINATION

A.   The ICS or packaged equipment system manufacturer shall design, engineer, fabricate, program, factory test, and deliver to the project site a complete and fully functional PLC to provide process monitoring and control of the specified equipment system and to interface with the Plant and/or District SCADA system.

B.   The manufacturer shall coordinate with the Contractor, Electrical Subcontractor, Instrumentation and Control Subcontractor, and District to ensure proper communication between PLC, Plant equipment, instrumentation and control devices, and SCADA system(s).

C.   The ICS or packaged equipment manufacturer shall provide qualified and experienced engineering representatives to participate in project software development and coordination workshops with the District. As a minimum, the manufacturer's representatives shall attend two (2) separate workshop sessions (one half day per session). The workshop sessions shall address the following:

1.   PLC I/O list. Conventions for tag names and addressing.

2.   PLC program monitoring and control strategy. PLC local/remote and auto/manual control modes.

3.   PLC communication and control approach (PLC to PLC, and SCADA to PLC).

4.   Network address assignments, where applicable.

5.   Alarm acknowledgment and reset strategy.

6.   Communication monitoring between PLCs and SCADA.

7.   Software security approach.

8.   Strategy for automatic restart following a power failure (Plant and equipment system).

9.   HMI screens (standard objects, data display, and color conventions).

D.   The manufacturer shall provide programming services incorporating direction received during the workshops with the District, including a complete monitoring and control logic program for operation of the equipment system. In addition, the manufacturer shall provide programming services for fully configured HMI screens.

E.   After the equipment system has been installed, the manufacturer shall perform pre-startup, startup, commissioning, and field testing of the system.

F.   Upon completion of system startup and testing, the manufacturer shall provide the District with a certificate of proper installation, and provide onsite training to District personnel.

1.10   QUALITY ASSURANCE

A.   The District believes that the manufacturers listed herein are capable of producing equipment and/or products that will satisfy the requirements of these Specifications. The listing of specific manufacturers herein does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed herein are not relieved from meeting these Specifications in their entirety; and, if necessary, they shall provide non-standard, custom equipment and/or products. Contractor shall be responsible for confirming that the proposed equipment and/or products will meet these Specifications.

B.   Products of one manufacturer and of the same series or family of models shall be used to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer support services.

PART 2 - PRODUCTS AND MATERIALS

2.01   PLC CAPABILITIES AND PERFORMANCE

A.   <u>General</u>

1.   The PLC shall collect data, perform process control functions, communicate with other PLCs, and distribute process information along the local area network.

2.	The PLC shall be capable of providing proportional, integral, and derivative control in real time, with preemptive priority multitasking.

3.	The PLC shall be able to have its program downloaded from a remote workstation over the local area network, and be locally programmed from a portable laptop computer.

4.	The executive firmware of all intelligent modules shall be stored in flash memory and shall be able to be updated in the field using standard programming tools. Executive firmware files shall be readily available via the PLC manufacturer's website.

5.	The PLC shall be field expandable to allow for the expansion of the system by the simple addition of hardware and configuration of same.

6.	A controller, or I/O module, shall be capable of being inserted under power, without upsetting the process being controlled by other controllers.

7.	The PLC shall have the capability to preselect the failure status of each output point in the event of CPU failure.

**2.02	PLC SOFTWARE REQUIREMENTS**

A.	Programming Software

As a minimum, the PLC programming software shall have the following capabilities:

1.	Allow the use of all textural and graphic languages specified in IEC 61131-3, including:

a.	Relay Ladder Diagram (LD)

b.	Function Block Diagram (FBD)

c.	Structured Text (ST)

d.	Sequential Function Chart (SFC)

The processor shall be able to program in all four languages in one processor. Standard Boolean logic for coils, timers/counters, etc., shall only be limited by the amount of memory in the processor.

2.   Data Manipulation:

      a.   All memory locations shall be tag based with the ability to add and delete online without taking the processor offline. In addition the tags shall have the ability to be named to reflect usage based on user conventions. The tags shall also have the ability to be aliased to other tag names if required.

      b.   Compare, move, block move, copy, and PID.

      c.   Table read/write/sort/compare/search/average.

3.   Math:

      a.   Add, subtract, multiply, and divide.

      b.   Square root, exponentiation, and logarithms (base ten and natural).

      c.   Floating point number accuracy of four places.

      d.   Engineering unit scaling function block for analog values.

4.   Documentation:

      a.   Address descriptions four lines by seven characters with edit, copy, and delete capability.

      b.   Rung descriptions with edit, copy, and delete capability.

      c.   Cut and paste logic capability.

      d.   Ability to import/export all documentation to/from standard text files.

5.   PID Blocks: support both dependent and independent equations.

6.   Support user defined data structures with mixed numeric types.

7.   Ability to store and retrieve instruction comments, program comments, rung comments, and other comments and notes in the PLC processor.

8.   Communications: support peer to peer message read and write.

9. The PLC programming software shall have the following tools for monitoring and troubleshooting the PLC program.

    a. A breakpoint capability to automatically halt the program just before a certain sequence is initiated.

    b. Ability to advance the program step by step to insure proper operation.

    c. Ability to create watch points for desired variables. These watch points shall display the real time value of the variable.

    d. Ability to create a table that will track a chosen variety of variables.

10. The PLC shall be programmed using a single programming software package. The programming software package shall have integrated tools for PLC programming, network configuration, and communication capabilities. PLC's that use separate programming, communication, and network configuration software will not be accepted. The programming software shall run on general purpose personal computers with Windows 10 (or latest) operating systems.

B. Editor

    1. The PLC programming software package shall include an IEC 61131-3 compliant editor.

    2. The logic editor shall support the creation of routines in all of the following four programming languages: LD, FBD, ST, and SFC.

    3. The editor and operating system shall support the import or export of specific, user-selected portions of logic, into and out of both a running controller as well as an offline controller configuration file. When performing this function online, the controller shall have a "test edit" function, such that the programmer can disqualify, or cancel the edit before fully accepting the changes.

C. Security

    The PLC system shall have capability to password protect access to the PLC. The system shall ensure security by authenticating users against a set of defined user accounts and access privileges.

2.03 PLC HARDWARE

A. General

The PLC shall be an integrated, modular, chassis type system designed for mounting the CPU (processor) module, I/O modules, communication modules, and power supply unit. The PLC shall be Allen Bradley 1756 ControlLogix or 1769 CompactLogix System (no substitutes).

B. Processor (CPU)

1. The PLC system shall execute logic in a single processor module. The processor shall be capable of executing all monitoring and control functions required by the Specifications and Drawings.

2. The processor shall have the ability to run multiple tasks with the ability to run each task at a particular scan rate that may be updated while running with the ability to prioritize each task.

3. Processor Features:

   a. Unless specified otherwise, the processor shall have a minimum of 4 MB of base program and data memory. Specified memory capacity shall be available entirely for storing the operational control program. Specified spare capacity and executive or "housekeeping" programs shall not be counted in memory size rating.

   b. A non-volatile memory card (EEPROM or Flash Memory) shall store the entire user program and configuration, and shall be capable of reloading the program into RAM if a fault in the program is detected or if the program is lost due to loss of battery power or other means. Unless specified otherwise, the non-volatile memory card shall have a minimum of 8 MB of memory.

   c. As a minimum, the processor shall be provided with one built-in USB port. The required 10BASE-T/100BASE-TX RJ45 Ethernet/IP ports shall be provided as built-in ports and/or via separate communication modules.

   d. The processor will be capable of being programmed with a general purpose laptop computer.

e.   The PLC shall use a lithium battery to back up the PLC RAM. A BAT light shall indicate when it is time to replace the battery.

f.   The PLC shall have status lights to indicate various functions, including run, processor fault, I/O fault, and communication activity.

C.   I/O Modules

1.   General Requirements

PLC I/O modules shall be provided as required to accept signals as indicated on the Drawings, as specified in Specifications for equipment, and as specified herein. I/O modules shall be provided to accept all active signals and all specified spares. PLC I/O modules, including installation in the PLC enclosure shall conform to the following:

a.   All I/O modules shall be enclosed in a plastic housing. I/O modules shall be plugged into a modular type I/O rack with common backplane. All cables required to connect to all other PLC system components shall be provided.

b.   I/O modules shall be capable of being removed and inserted into the I/O rack under power without affecting any other I/O modules in the rack.

c.   I/O of a particular type (digital inputs, digital outputs, analog inputs, and analog outputs) shall be grouped together.

d.   All I/O wiring shall be to removable terminal blocks that permit removal and replacement of a module without disturbing the wiring or any other I/O module. Removable terminal blocks shall be suitable for accepting #14 AWG I/O wiring.

e.   Identify on I/O modules and associated terminal blocks, the specific I/O points as they have been addressed in the PLC system.

f.   All field wiring shall be terminated on terminal blocks within the PLC enclosure. The field terminal blocks shall be sized to accommodate all active I/O points and required spares. Field terminals shall be provided for the individual termination of each analog signal shield. The PLC shall be factory prewired between the field terminal blocks and I/O module removable terminal blocks.

g. Unless specified otherwise, provide interposing relays for all discrete outputs. Relays shall be rated a minimum of 10A at 120VAC. Relays shall have LED status indicating lights.

h. Discrete I/O modules shall be provided with LED status indicating lights on the front of the module. One LED shall indicate I/O status of the field device (yellow – input/output is "on"). The other LED shall indicate module operating status (steady green – normal operating state, flashing green – not performing connected communication, and steady red – module failure).

i. Analog I/O modules shall be provided with LED status indicating lights on the front of the module. One LED shall indicate the module calibration status (green flashing – in calibration). A second LED shall indicate module operating status (steady green – normal operating state, flashing green – not performing connected communication, and steady red – module failure).

2. Basic I/O Modules

The manufacturer shall have available a variety of I/O modules for the PLC. I/O modules shall be selected as required for the particular project application. Unless specified otherwise, basic I/O modules shall conform to the following:

a. Discrete Inputs

1) Voltage rating shall match circuit voltage. Isolated I/O shall be provided for applications where module interfaces with devices utilizing different sources of power.

2) Discrete input modules shall be provided with individually isolated digital inputs, or non-isolated digital inputs (8 points per group), depending upon the application.

3) Discrete input modules shall be sixteen (16) channel 120VAC.

b. Discrete Outputs

1) Voltage rating shall match circuit voltage. Isolated I/O shall be provided for applications where module interfaces with devices utilizing different sources of power.

2) Discrete output modules shall be provided with individually isolated digital outputs, or non-isolated and mechanically fused digital outputs (8 points per group), depending upon the application.

3) Discrete output modules shall be sixteen (16) channel 120VAC relay.

4) Provide one (1) external fuse per common or per isolated output. Provide blown fuse indication. Fuses shall be in accordance with module manufacturer's specifications.

c. Analog Inputs

1) Analog input modules shall be provided with individually isolated analog inputs.

2) Analog input modules shall be eight (8) channel, 4-20mA DC (+/- 10V), with input impedance of 250 ohms per channel.

3) Analog input modules shall be provided with analog/digital (A/D) conversion resolution of 16 bits.

4) I/O chassis supplied power for powering connected field instruments.

d. Analog Outputs

1) Analog output modules shall be provided with individually isolated analog outputs.

2) Analog output modules shall be eight (8) channel, with each channel capable of driving a 4-20mA DC signal (+/- 10V) into a 0 to 600 ohm load.

3) Analog output modules shall be provided with digital/analog (D/A) conversion resolution of 16 bits.

e. Specialized I/O Modules:

1) Where required for the application, specialized I/O modules such as counter modules or high speed counter modules shall be provided.

2) All input/output signals and power supplies required for proper counter operation shall be provided.

D. Communications

1. Communications shall be capable of using Modbus, and open industry standard Ethernet/IP and OPC protocols.

2. The PLC shall be capable of peer-to-peer communications that provide for the direct transfer of process data between controllers without the use of gateways or servers.

3. Communication Capabilities: PLC chassis shall be capable of containing one or more communication modules to provide communication interfaces to other devices, including, but not limited to: remote work stations, HMIs, and PLCs by other manufacturers. As a minimum, the PLC shall support the following without the need for third-party modules:

a. Ethernet (10/100MB).

b. Serial protocols including Modbus and ASCII.

The PLC shall be provided with an Ethernet module equipped with multiple ports (a minimum of 2 ports, unless specified otherwise). Each port shall be capable of communicating both TCP/IP and Ethernet/IP simultaneously. Modules requiring the ports to be configured for one protocol will not be acceptable. The communication module shall also support daisy chain wiring.

4. Surge protection shall be provided on all connections to communication ports.

E. Chassis

The PLC shall be provided with a chassis to mount the processor module, I/O modules, communication modules, and other applicable modules. The chassis shall be modular, capable of accepting any module into any slot. The chassis backplane shall provide a high speed communication path between modules and distribute power to each of the modules within the chassis. Modules shall be secured to the chassis via a screw connection. The chassis shall be available in various slot configurations, up to a total of 17 slots.

F.   Power Supply Unit

PLC Power Supply Unit: Each PLC shall be provided with a regulated power unit designed to operate the PLC system. The power supply unit shall conform to the following:

1.   Mount directly to the chassis and connect to the chassis backplane.

2.   Provide power to:

a.   The PLC system, including the controller processor, I/O modules, communication modules, and other applicable modules.

b.   All associated two-wire field instruments.

c.   Other devices as indicated on the Drawings and/or Specifications.

3.   Capable of supplying PLC system power when all the specified spare I/O capacity is utilized.

4.   Sized to carry no more than 75 percent of total unit capacity under normal loads, including all spare capacity.

5.   Provide constant voltage level DC distribution to all devices. Power distribution shall be immune to transients and surges resultant from input power noise.

6.   A single power supply unit shall be provided for each chassis.

7.   Unless specified otherwise, the input power to the power supply shall be 120VAC, +/- 10 percent, 60 Hz.

8.   A separate line fuse shall be provided for each power supply unit.

G.   Uninterruptable Power Supply (UPS)

Uninterruptable Power Supply (UPS): Unless specified otherwise, each PLC shall be provided with a UPS. The UPS shall conform to the following:

1.   Ensure that transient power surges and dips do not affect the operation of the PLC system.

2.   Utilize low maintenance, rechargeable, sealed batteries, maintained at a float point charge during normal power conditions.

3. Provide a synchronized 60 Hz sine wave output, in-phase with the utility line power sine wave. The sine wave output shall be synchronized during switching from utility AC power source to battery source and during switching from battery source back to utility AC power source. The UPS switch to and from battery in less than 4 milliseconds.

4. Provide silencing audible and visible alarms indicating utility AC line power failure and low battery.

5. Provide a serial port interface to communicate with the panel PLC. This interface shall provide information to alert Plant and/or District SCADA of a low battery warning, power alarm, or UPS failure.

6. Sized to sustain full power to the following loads for a minimum of 15 minutes after loss of primary power:

   a. PLC power supply unit, including all chassis mounted PLC modules and associated two-wire field instruments.

   b. PLC Human-Machine Interface.

   c. All power supplies furnished with the PLC and associated loads.

7. Unless specified otherwise, the input power to the UPS shall be 120VAC, +/- 10 percent, 60 Hz. Output power from UPS shall be 120VAC, +/- 5 percent, 60 Hz. An AC circuit breaker shall be provided for the line power to the UPS.

8. The UPS shall be Model Smart-UPS, as manufactured by APC, or equal.

2.04 HUMAN-MACHINE INTERFACE (HMI)

Where specified, each PLC shall be provided with a door mounted Human-Machine Interface (HMI). Unless specified otherwise, each HMI shall meet or exceed the following requirements:

A. Display Size: 12 inches

B. Display Type: Touchscreen, backlit, color TFT LCD, 18-bit color graphics

C. Operating System: Microsoft Windows CE 6.0 R3

D. Architecture: Open

E.	Processor Frequency:	1.0 GHz
F.	RAM:	512 MB
G.	Internal Storage:	512 MB (80 MB non-volatile)
H.	Operating Temperature:	0 - 55°C
I.	Enclosure:	NEMA 4X, 12, and 13
J.	Input Power:	18-30VDC
K.	Interfaces:	1-SDHC card slot (store data/reload interface applications), 1-USB-A and 1-USB-B (v2.0 high speed)
L.	Communication Interfaces:	1-RJ45 10/100 MB, Auto MDI/MDI-X Ethernet port
M.	Standard Software:	FactoryTalk (Machine and Viewpoint) or equal, PDF Viewer, Active X Controls, Remote Terminal Control, FTP Server
N.	Manufacturer/Model:	Allen Bradley, PanelView Plus 7, or equal.

2.05 PLC ENCLOSURE AND APPURTENANCES

A.   The PLC enclosure shall be of sufficient size to house all PLC and HMI hardware, power supplies, instruments, relays, devices, terminal blocks, wireways, and appurtenances as specified herein and required for each equipment system application.

B.   Unless specified otherwise, PLCs located outdoors or indoors in corrosive or wet locations shall be provided with NEMA 4X enclosures constructed of Type 316 stainless steel. Unless specified otherwise, PLCs located indoors in non-corrosive and dry locations shall be provided with NEMA 12 enclosures. Enclosures shall be free-standing or wall mountable.

C.   NEMA 4X enclosures shall be provided with solid exterior door(s) and interior hinged swing-out door(s) for mounting HMIs, instrument displays, lights, switches, pushbuttons, etc. All PLC enclosures shall be supplied with removable equipment mounting back panels and padlockable doors equipped with 3-point latching systems, inner drawing holders, and neoprene seals.

D.   The interior and exterior of NEMA 4X stainless steel enclosures shall be unpainted. The interior of NEMA 12 enclosures shall be painted white and the exterior shall be painted gray. All enclosure interior mounting brackets, panels, and plates shall be painted white. Enclosures equipped with single doors shall be hinged to swing from right to left and shall be easily removable.

E.   Each PLC panel shall be provided with LED lighting fixtures of sufficient size and quantity to provide 50 foot-candles of illumination within the panel. The lighting fixtures shall be horizontal LED tube type fixtures and shall be mounted to the top of the enclosure. The light fixtures shall be wired to a UL-approved switch mounted inside the panel.

F.   Each PLC panel shall be provided with a duplex, 120VAC, 15A, 3-wire grounded GFCI type convenience receptacle.

G.   Unless indicated otherwise on the Drawings, the light fixture(s) and convenience receptacle shall be powered from a separate voltage source than the PLC equipment.

2.06   INTERPOSING RELAY SUBASSEMBLIES

A.   24 VDC interposing relays shall be utilized on all digital outputs which are required to interact with the motor control center, VFDs, valves and external hardwired logic circuitry. Octal socket plug-in relays containing two form "C" 10 amp contacts shall be supplied. Each relay shall contain an internal LED indicating when the relay has been energized. Relay coils shall be wired to the load side (output) of the supplied PLC field terminal block and labeled to reflect the I/O address which drives it. A 1 amp, 100V (1N4001) surge suppression diode shall be wired across the relay coil socket pins. Interposing relay contacts shall be wired with yellow wire to the line side (input) of a separate isolated field terminal block dedicated to interposing signals. All wires between relay contacts and the interposing signal terminal block shall be labeled to reflect the relay/pin number.

B.   Interposing relays shall be provided in subassemblies consisting of 4 relay sockets mounted onto an interposing relay mounting plate, and prewired with a color-coded wire harness for connection to terminal blocks, as described above. All hardware for mounting the subassembly into the PLC enclosure shall be provided, and a nameplate tag for relay identification shall be provided for each relay socket. Mounting of interposing relay subassemblies shall be simplified while maintaining the integrity of the enclosure's NEMA rating, maintaining serviceability without the removal of other equipment, and preventing interference with the removal or serviceability of other equipment.

2.07   WIRING

A.   All terminal blocks shall slide onto a single symmetrical steel DIN mounting rail. The terminal system shall be a finger-safe, multi-circuit (3 circuit minimum), compact, high-density design utilizing a stainless steel screw with nickel plated copper or brass pressure plate wire terminating construction. The terminal block system shall allow for installation ease where the addition of terminals simply requires sliding clear a space on the rail and snapping into place the new terminal modules. All terminals shall be rated for 600 volts with a maximum current of 20 amps, UL rated, and shall accommodate wires ranging between #24 to #12 AWG. All terminals shall have a place for marking the wire number associated with them. All terminal blocks shall be manufactured by Phoenix Contact, no substitutes.

B.   All analog inputs and outputs shall be terminated onto fused signal isolation terminal modules in order to protect the PLC I/O modules from accidental field wiring errors, ground loops, disparate supply voltages and short circuits. Power feeds, external power supply outputs, and other power distribution wiring to external equipment shall be terminated on a fused terminal. All fused terminal blocks shall be equipped with fuses, including all spare terminal blocks.

PART 3 – EXECUTION

3.01   FABRICATION

A.   The PLC chassis shall be mounted at the top of the enclosure back panel. Provide spacing around the PLC as required by the PLC manufacturer to ensure: adequate cooling, clearance space for cabling, and access for servicing. PLC communication ports, and memory card slots shall be accessible at all times. PLC lights shall be visible at all times when the enclosure door is opened.

B.   The field wiring terminal block subassemblies shall be located at the bottom of the enclosure back panel for easy access and routing of external wiring.

C.   The UPS and UPS power receptacle shall be located at the bottom of the enclosure

D.   The interposing relay subassemblies shall be mounted on the enclosure back panel or enclosure sides, whichever is most convenient for serviceability and panel size minimization while maintaining the NEMA rating. All relay sockets shall be prewired to terminals as described above.

E.   I/O modules shall be prewired with cable subassemblies to terminal blocks with color-coded (individually shielded pairs for analog signals) and neatly routed in an orthogonal fashion along the bottom of the PLC modules, panel sides and top of the terminal block subassemblies. Slotted wire ducts with removable covers shall be used for wire and cable routing. The number of cable subassemblies and type shall correspond to the number and type of I/O.

F.   Each PLC component shall include a clearly visible faceplate with appropriate data such as the manufacturer's model number. In addition, nameplates engraved with the name/function of each PLC component shall be provided. Each nameplate shall be mounted adjacent to the respective component in a clearly visible location.

G.   Each I/O point shall be identified on the door of the PLC I/O module.

H.   All cables and connectors required for proper operation of all PLC components and accessories shall be furnished by the manufacturer, and shall be factory installed and tested.

3.02   INSTALLATION

A.   Install the PLC panel in the location shown on the Drawings. Installation shall be in accordance with the manufacturer's written installation instructions and as specified herein.

B.   The PLC panel shall be rigidly support, plumb and level, and in such a manner as to provide accessibility and freedom from interference with other equipment, piping, or electrical work.

C.   Install free-standing PLC panels on a 3-inch high concrete housekeeping pad.

D.   Anchor panels in accordance with the manufacturer's recommendations, and equipment seismic anchorage calculations/details (where specified).

E.   All field wiring and cabling shall be connected to the PLC field terminal blocks in accordance with the approved shop drawings.

F.   All grounding shall be connected as shown on the approved shop drawings.

3.03   FIELD QUALITY CONTROL

The ICS or packaged equipment system manufacturer shall provide a qualified service representative to perform the following:

A.   Inspect the PLC, wiring, components, connections, and equipment installation. Perform all necessary pre-testing, operational checks, and adjustments of the supplied programmable controller, components, and equipment to ensure that the PLC is ready for operation.

B.   Assist in field testing of PLC and equipment system, including all programming for monitoring and control of the equipment.

C.   Provide a written report documenting all field testing and results.

D.   Provide written certification that the PLC system has been properly installed, started up, fully tested, and is ready for operation by the District.

3.04   FIELD TESTING

A.   After the PLC system installation has been certified and all analog points have been tested and calibrated, the entire system shall be tested to verify that on discrete and analog inputs and outputs are functioning correctly.

B.   I/O points shall be tested from end-to-end without simulation, to the maximum degree feasible without causing damage to the equipment. Simulated testing will only be allowed when no practical alternative exists.

C.   SCADA workstations shall be verified for correctness at the same time as the PLC testing.

D.   I/O checklists shall be provided by the ICS or packaged equipment manufacturer to record the test results, with a copy provided to the District upon completion of testing.

E.   Upon completion of the individual I/O points, system operational testing shall be performed. System operational testing shall demonstrate proper operation of the various process systems monitored and controlled by the PLC, including automatic control modes and control system interlocks. All specified functional requirements shall be verified for compliance.

F.   Tests that fail to demonstrate the required operation shall be repeated in their entirety after corrective action has been completed.

G.   During system testing, the ICS or packaged equipment manufacturer shall have a representative onsite continuously who is capable of troubleshooting and modifying the control system programming.

H.   Upon satisfactory completion of all field testing, the ICS or packaged equipment manufacturer shall submit a system testing report to the District documenting all performed testing and testing results.

3.05   TRAINING

A.   Upon satisfactory completion of all field testing and commission procedures, the ICS or packaged equipment manufacturer shall provide the services of a factory trained representative to provide onsite training of District personal in the operating and maintenance of the furnished equipment.

B.   Training shall include classroom and hands-on instruction. As a minimum, training shall address:

1.   PLC system hardware overview.

2.   PLC and HMI software overview.

3.   Service and maintenance.

4.   Troubleshooting.

5.   Operation, including program initiation, changing set points, manual overrides, passwords, etc.

END OF SECTION 17010

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