



**CITY OF MANTECA
MANTECA, CA**

SCADA STANDARDS

TECHNICAL SPECIFICATIONS

FINAL

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SECTION 16075

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Identification of electrical equipment, devices and components.
 - 2. Material, manufacturing and installation requirements for identification devices.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. Nameplates:
 - 1. Provide a nameplate for each piece of electrical equipment and devices, control panel and control panel components.
 - 2. Provide all nameplates of identical style, color, and material throughout the facility.
 - 3. Device nameplates information:
 - a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
- B. Wire numbers:
 - 1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
 - a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
 - b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
 - c. Internal panel wires on a common terminal shall have the same wire number.
 - d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
 - 1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers in Section 16130 - Conduits.

2. Provide the following wiring numbering schemes throughout the project for field wires between process control module, (PCM), vendor control panels, (VCP), motor control centers, (MCC), field starters, field instruments, etc.

(ORIGIN LOC.)–(ORIGIN TERM.)/(DEST. LOC.)–(DEST. TERM.)

OR

(ORIGIN LOC.)–(ORIGIN TERM.)
(DEST. LOC.)–(DEST. TERM.)

Where:

ORIGIN LOC. = Designation for originating panel or device
ORIGIN TERM. = Terminal designation at originating panel or device
DEST. LOC. = Designation for destination panel or device
DEST. TERM. = Terminal designation at destination panel or device or PLC

I/O address at destination panel:

- a. Identify equipment and field instruments as the origin.
- b. PCMs are always identified as the destination.
- c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
- d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
- e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g. T1, T2, T3, etc.).
- f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen-Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):
 - 1) Discrete Point: W:X:Y/Z.
Analog Point: W:X:Y.Z.
Where:
W = I for input, O for output
X = PLC number (1, 2, 3...)
Y = Slot number (01, 02, 03...)
Z = Terminal number (00, 01, 02...) for a discrete point or a word number for an analog point (1, 2, 3...)
- g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g. C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g. C0010A).

3. **Case 1:** Vendor control panel (VCP) to process control module (PCM):
Field wire number/label: A-B/C-D
A = Vendor control panel number without hyphen (VCP#)
B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)
C = Process control module number without hyphen (PCM#)
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
4. **Case 2:** Field instrument to process control module (PCM):
Field wire number/label: E-F/C-D
C = Process control module number without hyphen (PCM#)
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
E = Field mounted instrument tag and loop numbers without hyphen (EDV#)
F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma
5. **Case 3:** Motor control center (MCC) to process control module (PCM):
Field wire number/label: G-B/C-D
B = Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number)
C = Process control module without hyphen (PCM#)
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
G = Actual starter designation in the motor control center without hyphen (MMS#)
6. **Case 4:** Motor control center (MCC) to vendor control panel (VCP):
Field wire number/label: G-B/A-B
A = Vendor control panel number without hyphen (VCP#)
B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number)
G = Actual starter designation in the motor control center without hyphen (MMS#)
7. **Case 5:** Motor leads to a motor control center (MCC):
Field wire number/label: H-I/G-B
B = Terminal number within motor control center (manufacturer's standard terminal number)
G = Actual starter designation in the motor control center without hyphen (MMS#)
H = Equipment tag and loop number without hyphen (PMP#)
I = Motor manufacturer's standard motor lead identification (e.g. T1, T2, T3, etc.)

8. **Case 6:** Remote or separately mounted starter or variable frequency drive (VFD) to process control module (PCM):
Field wire number/label: J-B/C-D
B = Terminal number within starter or variable frequency drive (manufacturer's standard terminal number)
C = Process control module number without hyphen (VCP#)
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
J = Starter or variable frequency drive tag and loop number without hyphen (MMS#)
9. **Case 7:** Field bus trunk segment:
Field cable number/label: C/K-L/M; C/K-L/H; C/K-L/J
C = Process control module without hyphen (PCM#).
K = Field bus cable type.
L = Field bus segment number.
M = Field Bus field network component without hyphen (PTB1) or
H = Equipment tag and loop number without hyphen (EMV#) or
J = Starter or variable frequency drive tag and loop number without hyphen (VFD60.0112)
10. **Case 8:** Field bus spur (drop):
Field cable number/label: E/K-L/M
E = Field mounted instrument tag and loop numbers without hyphen (FIT#)
K = Field bus cable type.
L = Field bus segment number
M = Field bus field network component without hyphen (PTB1), identify ports on the device.
11. Identify all spare conductors as required for other field wires with an "S" prefix:

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 1. Nameplates:
 - a. Color.
 - b. Size:
 - 1) Outside dimensions.
 - 2) Lettering.
 - c. Material.
 - d. Mounting means.
 2. Nameplate schedule:
 - a. Show exact wording for each nameplate.
 - b. Include nameplate and letter sizes.
 3. Wire numbers:
 - a. Manufacturer's catalog data for wire labels and label printer.

- C. Record documents:
 - 1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Nameplates and signs:
 - 1. One of the following or equal:
 - a. Brady.
 - b. Seton.
- B. Conductor and cable markers:
 - 1. Heat-shrinkable tubing:
 - a. One of the following or equal:
 - 1) Raychem.
 - 2) Brady.
 - 3) Thomas & Betts.
 - 4) Kroy.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Nameplates:
 - 1. Colors:

- a. Warning nameplates: White-center, red face.
 - b. Other nameplates: Black-center, white face.
 - 2. Laminated plastic engraving stock:
 - a. 3/32-inch thick material.
 - b. 2-ply.
 - c. With chamfered edges.
 - 3. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
 - a. No characters smaller than 1/8-inch in height.
- B. Signs:
 - 1. Automatic equipment and high voltage signs:
 - a. Suitable for exterior use.
 - b. In accordance with OSHA regulations.
- C. Conductor and cable markers:
 - 1. Machine printed black characters on white tubing.
 - 2. 10 point type or larger.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Nameplates:
 - 1. Provide all nameplates for control panel operator devices (e.g. pushbuttons, selector switches, pilot lights, etc.):
 - a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.

- B. Nameplates:
 - 1. Attach nameplates to equipment with rivets, bolts or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
 - 2. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
 - 3. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
 - a. Misaligned or crooked nameplates shall be remounted, or provide new enclosures at the discretion of the Engineer.
- C. Conductor and cable markers:
 - 1. Apply all conductor and cable markers before termination.
 - 2. Heat-shrinkable tubing:
 - a. Tubing shall be shrunk using a heat gun that produces low temperature heated air.
 - b. Tubing shall be tight on the wire after it has been heated.
 - c. Characters shall face the open panel and shall read from left to right or top to bottom.
 - d. Marker shall start within 1/32 inch of the end of the stripped insulation point.
- D. Signs and labeling:
 - 1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
 - a. Fasten warning signs with round head stainless steel screws or bolts.
 - b. Locate and mount in a manner to be clearly legible to operations personnel.
 - 2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc. where the voltage exceeds 600 volts.
 - 3. Furnish and install warning signs on equipment that has more than one source of power.
 - a. Warning signs to identify every panel and circuit number of the disconnecting means of all external power sources.
 - 4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
 - a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in General Conditions.

3.08 FIELD QUALITY CONTROL

- A. Replace any nameplates, signs, conductor markers, cable markers or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17050

COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. General requirements applicable to all Process Control and Instrumentation Work.
 - 2. General requirements for process control and instrumentation submittals.
- B. Interfaces to equipment, instruments, and other components:
 - 1. Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
 - 2. Provide all material and labor needed to install the actual equipment furnished, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be necessary to make a complete, functional installation based on the actual equipment furnished:
 - a. Make all changes necessary to meet the manufacturer's wiring requirements.
 - 3. Submit all such changes and additions to the Engineer for acceptance as specified in the General Conditions.
 - 4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items indicated on the Drawings or in Specifications from another discipline in the scope of Work:
 - a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
 - 5. Loop drawings:
 - a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and for all pre-purchased equipment.
 - b. The form, minimum level of detail, and format for the loop drawings must match that of the sample loop drawings included in the Contract Documents.
 - c. The Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor furnished equipment.
- C. All instrumentation, and control equipment and systems for the entire project to comply with the requirements specified in the Instrumentation and Control Specifications, whether referenced in the individual Equipment Specifications or not:

1. The requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in other Specifications, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
 2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of the Instrumentation and Control Specifications.
 3. The Owner is not responsible for any additional costs due to the failure of the Contractor to notify all subcontractors and suppliers of the Instrumentation and Control Specifications' requirements.
- D. Special subcontractor requirements:
1. As specified elsewhere in this Section and in Section 17051 - Prequalification of Instrumentation and Control System Contractor, provide the Work specified in the Instrumentation and Control Specifications by a pre-qualified instrumentation and control system contractor (ICSC).
- E. Contract Documents:
1. General:
 - a. The drawings and specifications are complementary and are to be used together in order to fully describe the Work.
 2. Specifications:
 - a. The General Conditions of the Contract Documents govern the Work.
 - b. These requirements are in addition to all General Requirements.
 3. Contract drawings:
 - a. The Instrumentation and Control Drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the Instrumentation Work. Follow the drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation, use the entire drawing set for construction purposes.
 - b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the Work to ensure the best possible installation:
 - 1) The equipment locations and dimensions indicated on the Drawings and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
 - 2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual Specifications; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
 - c. Installation details:
 - 1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary

for completing the Work, and submit these details for review by the Engineer.

- d. Schematic diagrams:
 - 1) All controls are shown de-energized.
 - 2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
 - 3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
 - 4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
 - 5) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences indicated on the Drawings or in the Specifications. Combine all information and furnish a coordinated and fully functional control system.

- F. Alternates/Alternatives:
 - 1. Substitute item provisions as specified in the General Conditions.
- G. Changes and change orders:
 - 1. As specified in the Contract Documents.

1.02 REFERENCES

- A. Code compliance:
 - 1. As specified in the Contract Documents:
 - a. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs.
 - 2. The following codes and standards are hereby incorporated into this Section:
 - a. American National Standards Institute (ANSI).
 - b. American Petroleum Institute (API):
 - 1) RP 550 - Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.
 - 2) RP 551 - Process Measurement Instrumentation.
 - c. International Organization for Standardization (ISO):
 - 1) 9001 - Quality Management Systems - Requirements.
 - d. International Society of Automation (ISA):
 - 1) 5.1 - Instrumentation Symbols and Identification.
 - 2) 5.4 - Instrument Loop Diagrams.
 - 3) 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
 - e. National Electrical Manufacturers Association (NEMA):
 - 1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
 - f. National Fire Protection Association (NFPA).
 - g. National Institute of Standards and Technology (NIST).
 - h. Underwriters Laboratories, Inc. (UL):
 - 1) 508 - Standard of Safety for Industrial Control Equipment.

2) 508A - Standard of Safety for Industrial Control Panels.

- B. Compliance with Laws and Regulations:
1. As specified in the General Conditions.

1.03 DEFINITIONS

- A. Definitions of terms and other electrical and instrumentation considerations in accordance with:
1. Factory Mutual (FM).
 2. International Electrotechnical Commission (IEC).
 3. Institute of Electrical and Electronics Engineers (IEEE).
 4. International Society of Automation (ISA).
 5. International Organization for Standardization (ISO).
 6. National Electrical Code (NEC).
 7. National Electrical Manufacturers Association (NEMA).
 8. InterNational Electrical Testing Association (NETA).
 9. National Fire Protection Association (NFPA).
 10. National Institute of Standards and Technology (NIST).
 11. Underwriters Laboratories (UL).
- B. Specific definitions:
1. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
 2. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems.
 3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
 4. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.
 5. Digital bus: A communication network, such as PROFIBUS, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions, and diagnostic information.
 6. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides a signal such as 4 to 20 mA 24VDC regulation of a signal in a series circuit with an external 24 VDC driving potential:
 - a. Fieldbus communications signal or both.
 7. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 mA 24VDC signal, a digital bus communications signal, or both.
 8. System supplier - As specified in ICSC Qualifications in the Quality Assurance article of this Section.
 9. Modifications: Changing, extending, interfacing to, removing, or altering an existing circuit.

C. Acronym definitions:

1. ACB: Automatic current balance.
2. ATS: Automatic Transfer Switch.
3. CCS: The PCS central computer system (CCS) consisting of computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.
4. DPDT: Double-pole, double-throw.
5. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
6. FAT: Factory acceptance test also known as Source Test.
7. HART: Highway addressable remote transducer.
8. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
9. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically information is displayed in a graphical format.
10. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
11. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
12. I/O: Input/Output.
13. IP: Internet protocol or ingress protection.
14. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
15. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
16. LOI: Local Operator Interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface.
17. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
18. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO, etc.
19. P&ID: Process and instrumentation diagram.

20. PC: Personal computer.
21. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings. This includes all the PCS and instruments and networking components as well as the various servers, workstations, thin clients, etc.
22. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
23. PCS: Process Control System: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, LOIs, HMIs, both LCPs, VCPs and all data management systems accessible to staff.
24. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
25. PLC: Programmable logic controller.
26. PS: Power supply.
27. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.
28. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
29. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations, etc.
30. SPDT: Single-pole, double-throw.
31. SPST: Single-pole, single-throw.
32. UPS: Uninterruptible power supply.
33. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, LOI, HMI, etc.
34. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

1.04 SYSTEM DESCRIPTION

- A. General requirements:
 1. The Work includes everything necessary for and incidental to executing and completing the instrumentation and control system work indicated on the Drawings and specified in the Specifications and reasonably inferable there from including but not limited to:
 - a. Preparing hardware submittals for field instrumentation.
 - b. Design, develop, and draft loop drawings, control panel designs, and all other drawing submittals specified in the Instrumentation and Control Specifications.
 - c. Prepare the test plan, the training plan, and the spare parts submittals.
 - d. Procure all hardware.
 - e. Provide all PCS system hardware.
 - f. Provide all PCS system software.
 - g. Fabricate panels.

- h. Perform factory tests on panels.
 - i. Perform bench calibration and verify calibration after installation.
 - j. Oversee and certify installation of the PCS system.
 - k. Oversee, document, and certify loop testing.
 - l. Oversee, document, and certify system.
 - m. Installation Testing.
 - n. Oversee and document Functional Testing.
 - o. Conduct the Process Operational Period and the Instrumentation and Controls Process Performance Testing.
 - p. Prepare operation and maintenance manuals.
 - q. Conduct training classes.
 - r. Integrate the PCS with instrumentation and control devices provided under other sections.
 - s. Provide Record Drawings and Loop Drawings associated with Instruments and equipment:
 - 1) As specified in the Contract Documents.
 - 2) For Owner furnished items.
 - 3) For interfaces with existing equipment.
 - t. Resolve signal, power, or functional incompatibilities between the PCS and interfacing devices.
 - u. Perform all required corrective and preventative maintenance.
2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of all equipment furnished by others, as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
 3. Provide the complete operating PCS to perform the specified monitoring, communications, alarm, control, display, and reporting functions in accordance with the PCS requirements.
 4. Coordinate all aspects of the Work between Contractor and all subcontractors before bidding to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the ICSC, the other subcontractors, or suppliers.
 5. Furnish detailed, complete, and thorough operations and maintenance documentation, including but not limited to operations manuals, maintenance manuals, as-built wiring drawings, training manuals, as-built software documentation, and all other documentation required to operate, modify, and maintain all parts of the PCS.
 6. Where demolition is indicated on the Drawings, the electrical subcontractor is responsible for disconnecting equipment electrical connections and rendering the equipment safe. The ICSC is responsible for physically removing all instrumentation to be demolished and return it either to the Owner or dispose of it as directed by the Owner's representative. The ICSC shall be responsible for any program modifications needed based on the demolition of the equipment, both for the loops directly and indirectly affected.
 7. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment.

- a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before performing any Work.
 - b. Provide and document interface with, modifications to, upgrade, or replacement of existing circuits, power systems, controls, and equipment.
- 8. Revise in a manner as directed by the Engineer all I/O and addressing that the Engineer determines to be unacceptable as a result of a lack of Contractor coordination between Contract Documents and all suppliers.
- 9. Defective Work:
 - a. As specified in the General Conditions.
- B. Existing system:
 - 1. This project is a control system upgrade that encompasses many automation upgrades. The project will require implementation in several phases as specified in the Contract Documents. Each phase will need to be planned and fully executed as if they were individual projects. This includes submittals, programming development meetings, testing, and training.
- C. Operating facility:
 - 1. As specified in the Contract Documents.
 - 2. Portions of this existing facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
 - a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction to meet the requirements of the Owner.
 - b. As weather and facility demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
 - c. Where portions of the Work are in existing facilities and require interface to existing circuits, power systems, controls and equipment, perform comprehensive and detailed field investigations of existing conditions. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
 - d. Temporary control systems:
 - 1) Provide temporary controls in order to keep the facility fully operational during Work on the electrical and control systems.
 - 3. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
 - 4. Where shown or specified, replace existing field instruments with new.
 - 5. Contractor is responsible for the integrity and measurement accuracy of all loops.
 - 6. Any defect found in existing equipment is the responsibility of the Owner. Contractor is not responsible for defects on existing Owner components.
 - 7. The standards of documentation, instrument tagging, cable and conductor termination, terminal identification and labeling that apply to the new installation apply equally to the existing installation.

1.05 SUBMITTALS

- A. Furnish submittals as specified in the Contract Documents and this Section.
- B. General:
 - 1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
 - 2. Furnish the submittals required by each section in the Instrumentation Specifications.
 - 3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:
 - a. Uniquely number each wire.
 - b. Wire numbers must appear on all Equipment Drawings.
 - 4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.
- C. Submittal organization:
 - 1. First page:
 - a. Specification section reference.
 - b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
 - c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
 - d. Comments.
 - e. Contractor's review certification statement and signature.
 - 2. Next pages:
 - a. Provide confirmation of specification compliance:
 - 1) Specification section: Include with each submittal a copy of the relevant specification section.
 - a) Indicate in the left margin, next to each pertinent paragraph, either compliance with a check (✓) or deviation with a consecutive number (1, 2, 3).
 - b) Provide a list of all numbered deviations with a clear explanation and reason for the deviation.
 - b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:
 - 1) In the order that the comments or questions were presented throughout the submittal.
 - 2) Referenced by index section and page number on which the comment appeared.
 - 3) Acceptable responses to Engineer's comments are either:
 - a) Engineer's comment or change is accepted and appropriate changes are made.
 - b) Explain why comment is not accepted or requested change is not made.
 - c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
 - 4) Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.
 - 5) No further review by the Engineer will be performed until a response for previous comments has been received.
 - 3. Remaining pages:

- a. Actual submittal data:
 - 1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.
 - 2) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.
- D. Submittal requirements:
 - 1. Furnish submittals that are fully indexed with a tabbed divider for every component.
 - 2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
 - 3. Furnish submittals in the following general order, each in a separate bound set:
 - a. Schedule of Values.
 - b. Product Data.
 - c. After Engineer acceptance of the Product Data, submit the Project Shop Drawing submittals.
 - d. Loop Description Submittal.
 - e. The Process Control Hardware and Software Submittal including, control system software, programming, and screens.
 - f. Testing, Calibration and Process Start-Up procedures.
 - g. Operation and Maintenance Data.
 - h. Training Submittals.
 - i. Record Documents.
 - 4. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
 - a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
 - 5. Submit copies of shop drawings, and product data:
 - a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
 - 6. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
 - a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
 - 7. Exceptions to Specifications and Drawings:
 - a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
 - b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
 - c. Acceptance of any exception is at the sole discretion of the Engineer.

- 1) Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
 - d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.
- E. Submittal preparation:
1. During the period of preparation of submittals, the Contractor shall authorize direct, informal liaison between the ICSC and the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions may be authorized informally by the Engineer, which do not alter the scope of Work or cause increase or decrease in the Contract price or times. During this informal exchange, no oral statement by the Engineer shall be construed to give formal approval of any component or method, nor shall any statement be construed to grant exception to, or variation from, these Contract Documents.
 2. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
 - a. Employ the nomenclature and numbers designated in this Section and indicated on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
 - b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, suppliers, or subcontractor's standard methods with those identified in this Section and indicated on the Drawings.
- F. Specific submittal requirements:
1. Shop drawings:
 - a. Required for materials and equipment listed in this and other sections.
 - b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
 - c. Shop drawings requirements:
 - 1) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
 - 2) Locations of conduit entrances and access plates.
 - 3) Component layout and identification.
 - 4) Schematic and wiring diagrams with wire numbers and terminal identification.
 - 5) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
 - 6) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
 - 7) Weight.
 - 8) Finish.
 - 9) Nameplates:
 - a) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
 - 10) Temperature limitations, as applicable.

- d. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
 - e. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
 - 1) Uniquely number each wire per the Specifications.
 - f. Wire numbers must appear on all equipment drawings.
 - g. Organize the shop drawing submittals for inclusion in the Operation and Maintenance Manuals:
 - 1) Furnish the initial shop drawing submittal bound in one or more standard size, 3-ring, D-ring, loose-leaf, vinyl plastic, hard-cover binders suitable for bookshelf storage.
 - 2) Binder ring size: 2 inches.
 - h. Include the letterhead and/or title block of the firm responsible for the preparation of all shop drawings. Include the following information in the title block, as a minimum:
 - 1) The firm's registered business name.
 - 2) Firm's physical address, email address, and phone number.
 - 3) Owner's name.
 - 4) Project name and location.
 - 5) Drawing name.
 - 6) Revision level.
 - 7) Personnel responsible for the content of the drawing.
 - 8) Date.
 - i. The work includes modifications to existing circuits:
 - 1) Clearly show all modifications to existing circuits.
 - 2) In addition, show all existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
2. Product data:
- a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
 - b. Include:
 - 1) Catalog cuts.
 - 2) Bulletins.
 - 3) Brochures.
 - 4) Quality photocopies of applicable pages from these documents.
 - 5) Identify on the data sheets the Project name, applicable specification section, and paragraph.
 - 6) Identify model number and options for the actual equipment being furnished.
 - 7) Neatly cross out options that do not apply or equipment not intended to be supplied.
 - c. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
 - d. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
 - 1) Uniquely number each wire per the Specifications.
 - e. Wire numbers must appear on all equipment drawings.
3. Detailed sequence of operation for all equipment or systems.
4. Operation and maintenance manuals:
- a. As specified in the Contract Documents and this Section.

- b. Submit preliminary sets of these manuals to the Engineer for review of format and content:
 - 1) Engineer will return 1 set with comments.
 - 2) Revise and/or amend as required and submit the requisite number of copies to the Engineer 15 days before Functional Testing of the systems.
- c. Incorporate changes that occur during process start-up and submit as part of the final manuals.
- d. Provide comprehensive information on all systems and components to enable operation, service, maintenance, and repair.
- e. Include Record Documents and the accepted shop drawing submittals, modified for conditions encountered in the field during the work.
- f. Include signed results from Functional Testing and Process Operational Period.
- g. Provide installation, connection, operating, calibration, setpoints (e.g., pressure, pump control, time delays, etc.), adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.
- h. Provide exploded or other detailed views of all instruments, assemblies, and accessory components together with complete parts lists and ordering instructions.
- i. Spare parts list:
 - 1) Include a priced list of recommended spare parts for all the equipment furnished under this Contract:
 - a) Include recommended quantities sufficient to maintain the furnished system for a period of 5 years.
 - 2) Annotate the list to indicate which items, if any and quantity are furnished as part of this Contract.
- j. Provide the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts.
- k. Additional operation and maintenance manual requirements:
 - 1) Completely index manuals with a tab for each section:
 - a) Provide a pdf document with links between sections and related content.
 - b) Each section containing applicable data for each piece of equipment, system, or topic covered.
 - c) Assemble manuals using the accepted shop drawings, and include, the following types of data:
 - (1) Complete set of 11-inch by 17-inch drawings of equipment.
 - (2) Complete set of 11-inch by 17-inch drawings of the control system.
 - (3) Complete set of control schematics.
 - (4) Complete parts list for all equipment being provided.
 - (5) Catalog data for all products or equipment furnished.
- l. Operational Manual:
 - 1) Prepare and provide a simplified version of the standard manufacturer's HMI software and system operations manual that includes basic instructions in the application of the system as required for operators in day-to-day operations.
- m. Control System Software Record Documents:
 - 1) Include complete documentation, in native format, of all the software programs provided for the entire control and PCS system, including:

- a) Listings of all application software on both hard copy and DVD, DVD-ROM, and CD-ROM.
 - b) Database, both hard copy and DVD, DVD-ROM, and CD-ROM.
 - c) Communication protocols.
 - d) All documentation necessary to maintain, troubleshoot, modify, or update the software system.
- n. Organize the operation and maintenance manuals for each process in the following manner:
 - 1) Section A - Process and Instrumentation Diagrams.
 - 2) Section B - Control Descriptions.
 - 3) Section C - Loop Drawings.
 - 4) Section D - Instrument Summary.
 - 5) Section E - Instrument Data Sheets and Brochures.
 - 6) Section F - Sizing Calculations.
 - 7) Section G - Instrumentation Installation Details.
 - 8) Section H - Test Results.
 - 9) Section I - Operational Manual.
 - 10) Section J - Spare Parts List.
 - 11) Section K - Control System Software.
- 5. Material and equipment schedules:
 - a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
 - 1) Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
- 6. Itemized instrument summary:
 - a. Submit a hard copy of the instrument summary.
 - b. List all of the key attributes of each instrument including:
 - 1) Tag number.
 - 2) Manufacturer.
 - 3) Model number.
 - 4) Service.
 - 5) Area location.
 - 6) Calibrated range.
 - 7) Loop drawing number.
 - c. Associated LCP, VCP, PCM, or PLC.
- 7. Instrument data sheets and cut sheets:
 - a. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hard copy, for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves. The data sheets provided with the instrument specifications are preliminary and are not complete. They are provided to assist with the completion of final instrument data sheets. Additional data sheets may be required. Include the following information on the data sheet:
 - 1) Component functional description specified in this Section and indicated on the Drawings.
 - 2) Manufacturers model number or other product designation.
 - 3) Tag number specified in this Section and indicated on the Drawings.
 - 4) System or loop of which the component is a part.
 - 5) Location or assembly at which the component is to be installed.
 - 6) Input and output characteristics.
 - 7) Scale range with units and multiplier.

- 8) Requirements for electric supply.
- 9) Requirements for air supply.
- 10) Power consumption.
- 11) Response timing.
- 12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
- 13) Special requirements or features, such as specifications for ambient operating conditions.
- 14) Features and options that are furnished.
- b. Provide a technical brochure or bulletin ("cut sheet") for each instrument on the project. Submit with the corresponding data sheets:
 - 1) Where the same make and model of instrument is used in 2 or more applications on the project, and the process applications are nearly identical, and the materials, features and options are identical submit one brochure or bulletin for the set of identical instruments.
 - 2) Include a list of tag numbers for which it applies with each brochure or bulletin.
 - 3) Furnish technical product brochures that are complete enough to verify conformance with all Contract Document requirements, and to reflect only those features supplied with the device.
 - 4) Cross out models, features, options, or accessories that are not being provided.
 - 5) Clearly mark and identify special options and features.
- c. Organization: Index the data sheets and brochures in the submittal by systems or loops.
8. Control panel hardware submittal:
 - a. Submit the following in 1 submittal package.
 - b. Complete and detailed bills of materials:
 - 1) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
 - 2) Include all items within an enclosure.
 - c. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and Control System equipment.
 - d. Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium voltage power cables.
 - e. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.
 - f. Provide a data sheet for each control system component together with a technical product brochure or bulletin, which include:
 - 1) The manufacturer's model number or other identifying product designation.
 - 2) Tag and loop number.
 - 3) System to which it belongs.
 - 4) Site to which it applies.
 - 5) Input and output characteristics.
 - 6) Requirements for electric power.
 - 7) Device ambient operating requirements.
 - 8) Materials of construction.
9. Schedule of values:

- a. In addition to completing all items referred to in the schedule of values submit per unit instrument and labor costs used in developing the final bid for the PCS system, for the express purpose of pricing and cost justification for any proposed change orders. It is the responsibility of the ICSC subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.
- 10. Installation recommendations:
 - a. Submit the manufacturer's printed recommendations for installation of instrumentation equipment.
- 11. Training submittals:
 - a. Develop and submit for review a general training plan for approval by Owner within 14 calendar days from Notice to Proceed. Include complete descriptions of all planned training classes, a preliminary training schedule, a list of all proposed instructors along with resumes, examples of proposed training manuals, and a description of any special training tools to be used (simulators, self-paced modules, personal computer-based training, etc.).
 - b. The Engineer will review the general training plan. Special emphasis will be placed on review of the qualifications of the proposed instructors and the timing of the individual courses to maximize their effectiveness. If, in the opinion of the Engineer, the proposed instructors are not sufficiently qualified to conduct the specified training courses, or lack experience, where required, on the specific configuration of the system, provide more qualified instructors.
 - c. The general training plan and schedule shall be updated by the Contractor at the beginning of each Phase and approved by the Owner a minimum of 30 days prior to commencement of training.
 - d. Training course plan submittals:
 - 1) For each training course or other training activity, submit a detailed, complete outline and agenda for each lesson.
 - 2) Describe any student pre-requisites for the course or training activity.
 - 3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.
 - 4) Submit training materials.
 - e. Incorporate all submittal review comments into the course.
 - f. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.
- 12. Project Record documents:
 - a. Furnish as specified in the Contract Documents and this Section.
 - b. Record Drawing requirements:
 - 1) Provide Project Record Drawing of all Instrumentation Drawings.
 - 2) Update Record Drawings weekly.
 - 3) Record Drawings must be fully updated as a condition of the monthly progress payments.
 - 4) Clearly and neatly show all changes including the following:
 - a) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
 - c. Shop drawings:
 - 1) General:
 - a) Coordinate all aspects of the Work so that a complete, instrumentation, computer, and control system for the facility is supported by accurate shop and record drawings:

- (1) Clearly show every wire, circuit, and terminal provided under this contract on one or more submitted wiring diagrams.
- b) Show all interfaces between any of the following: instruments, vendor control panels, motor control centers, motor starters, variable speed drives, control valves, flow meters, chemical feeders, and other equipment related to the PCS.
- c) Generate all drawings developed for this project utilizing AutoCAD by Auto Desk Version 2012 or later:
 - (1) Furnish on CD-ROM disks containing the following for each drawing:
 - (a) Original CAD files in DWG format.
 - (b) PDF version.
 - (2) Provide hard copies on 11-inch by 17-inch plain bond paper.
- d) Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
 - (1) Should an error be found in a shop drawing during installation or process start-up of equipment, note the correction, including any field changes found necessary, on the drawing and submit the corrections in the Record Documents.
 - (2) Update, check, and revise all wiring drawings and other submitted drawings and documents to show final installed conditions.
 - (3) Provide as-built shop drawings for all instrumentation equipment on 11-inch by 17-inch using plain bond paper.
 - (4) Provide electronic copies of these documents on CD-ROM disks in AutoCAD DWG 2010 format or later and PDF format. Size all drawings to be readable and legible on 11-inch by 17-inch media.
- e) Submittal Documents:
 - (1) Provide an interim submittal of Record Documents after the PCS system Functional Testing.
 - (2) Submit final Record Documents before Substantial Completion or earlier if so specified in the Contract Documents.
- f) Review and Corrections:
 - (1) Correct any Record Documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
 - (2) Promptly correct and re-submit Record Documents returned for correction.
- 2) Furnish written information prepared specifically for this Project using Microsoft Word and PDF formats and printed on 8.5-inch by 11-inch plain bond paper:
 - a) Provide electronic copies of these documents on CD-ROM disks.
- d. Review and corrections:
 - 1) Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.

- 2) Promptly correct and re-submit record documents returned for correction.
13. Loop Drawings:
 - a. Submit loop drawings for every analog, discrete, and fieldbus signal and control circuit:
 - 1) Provide a loop drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop on this Project.
 - 2) This requirement applies to all signal and control circuits associated with equipment on this Project including vendor supplied equipment packages and control panels.
 - 3) Provide loop drawings in the format indicated in the contract drawings. Provide all tagging in accordance with the Owner's standard.
 - b. Show every instrument and I/O point on at least one loop diagram.
 - c. Provide a complete index in the front of each bound volume:
 - 1) Index the loop drawings by systems or process areas.
 - d. Provide drawings showing definitive diagrams for every instrumentation loop system:
 - 1) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
 - 2) Furnish a separate drawing sheet for each system or loop diagram.
 - e. In addition to the ISA-5.4 requirements, show the following details:
 - 1) Functional name of each loop.
 - 2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
 - 3) Show all terminal numbers, regardless of the entity providing the equipment.
 - 4) MCC panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
 - 5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
 - 6) Show vendor control panel, instrument panel, conduit, junction box, equipment and PCS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
 - 7) If a circuit is continued on another drawing, show the name and number of the continuation drawing on the loop drawing. Provide complete references to all continuation drawings whether vendor control panels, other loop drawings, existing drawings provided by the Owner, or other drawings.
 - f. In addition to the above requirements, provide loop diagrams in accordance with the example loop diagram as indicated on the Drawings.
14. Instrument Installation Drawings:
 - a. Submit, instrument installation, mounting, and anchoring details for all components and assemblies, including access requirements and conduit connection or entry details.
 - b. Furnish for each instrument a dedicated 8 1/2-inch by 11-inch installation detail that pertains to the specific instrument by tag number.
 - c. For each detail, provide certification and the hard copies, by the instrument manufacturer, that the proposed installation is in accordance

with the instrument manufacturer's recommendations and is fully warrantable.

- d. For each detail, provide, as a minimum, the following contents:
 - 1) Necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
 - 2) Ambient temperature and humidity where the instrument is to be installed.
 - 3) Corrosive qualities of the environment where the instrument is to be installed.
 - 4) Hazardous rating of the environment where the instrument is to be installed.
 - 5) Process line pipe or tank size, service and material.
 - 6) Process tap elevation and location.
 - 7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
 - 8) Routing of tubing and identification of supports.
 - 9) Mounting brackets, stands, anchoring devices, and sun shades.
 - 10) Conduit entry size, number, location, and delineation between power and signal.
 - 11) NEMA ratings of enclosures and all components.
 - 12) Clearances required for instrument servicing.
 - 13) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.
- 15. Control Panel Drawings:
 - a. Layout Drawings:
 - 1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
 - 2) As a minimum, include the following information:
 - a) To scale front, side, and plan views.
 - b) Dimensions.
 - c) Interior and exterior arrangements.
 - d) Mounting information, including conduit entrance location.
 - e) Finish data.
 - f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
 - g) Nameplate legend including text, letter size, materials, and colors.
 - b. Wiring and piping diagrams:
 - 1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
 - 2) Include the following information:
 - a) Name of panel.
 - b) Wiring and piping sizes and types.
 - c) Terminal strip numbers.
 - d) Wire tags and labels.
 - e) Functional name and manufacturer's designation for items to which wiring and piping are connected.
 - f) Electrical control schematics in accordance with ANSI standards.

- c. Installation drawings:
 - 1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
 - 2) Provide scaled drawings and show the position of the equipment at its intended installation location.
 - 3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.
 - 4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.
- 16. Schematic Diagrams:
 - a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
 - b. Include device and field connection terminal numbers on all schematic diagrams.
 - c. Incorporate equipment manufacturer's shop drawing information into the schematic diagrams in order to document the entire control system.
- 17. Control System Diagram:
 - a. Submit a complete set of control system diagrams including the following information:
 - 1) All PLCs, workstations, printers, communication devices, and communication links:
 - a) Show all PLCs with their current I/O allocation, and future I/O allocation, current plus spares provided, and maximum potential I/O based on available slots.
 - 2) All cables required for communication requirements.
 - 3) Show each component fully annotated with conduit size and number associated with the power source.
- 18. Process Control Software Submittal:
 - a. In accordance with Product Data and Shop Drawing general requirements.
 - b. Submit a complete description of the standard application software programs, operating system and utility programs, including modifications and explanation of how the specific functional requirements are met:
 - 1) Provide a cross-reference between the Specification requirements and the software submittal, in order to provide the Engineer the ability to identify how each specified requirement or function is met.
 - c. A complete listing of the PCS system point I/O database:
 - 1) Include for each data point, relevant parameters such as range, contact orientation, limits, incremental limits, I/O card byte, I/O hardware address, and PLC assignment.
 - 2) Organize on a site-by-site basis, separate by point type.
 - 3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
 - 4) Upon completion of the Work, update all I/O lists to indicate the final as-built configuration of the systems:
 - a) Organize as-built I/O list on a site-by-site basis, separated by equipment and point type.
 - d. Detailed descriptions of procedures used to implement and modify control strategies and database construction.

- e. Preliminary overview, screens, station graphic displays, and preliminary reports.
- 19. Instrumentation and Control System Contractor Statement of Qualifications:
 - a. Submit statement of qualifications of the proposed ICSC in accordance with subsequent requirements of this Section.
- 20. Control Descriptions:
 - a. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls as shown on the P&IDs:
 - 1) Include all functions depicted or described in the Contract Documents.
 - 2) Include within the Control Description content:
 - a) All specific requirements.
 - b) All common requirements that pertain in general to all loops.
 - c) Listing all ranges, setpoints, timers, values, counter values, etc.
- 21. Test Procedure Submittals:
 - a. Submit the proposed procedures to be followed during tests of the PCS and its components in 2 parts:
 - 1) Preliminary Submittal: Outline of the specific proposed tests and examples of proposed forms and checklists.
 - 2) Detailed Submittal: After successful review of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and checklists. Include a statement of test objectives with the test procedures.
- 22. Test reports:
 - a. As specified in the Contract Documents and this Section.
 - b. Include the following:
 - 1) A description of the test.
 - 2) List of equipment used.
 - 3) Name of the person conducting the test.
 - 4) Date and time the test was conducted.
 - 5) All raw data collected.
 - 6) Calculated results.
 - 7) Each report signed by the person responsible for the test.
- 23. Calculations:
 - a. Where required by specific Instrumentation Specifications:
 - 1) Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

1.06 QUALITY ASSURANCE

- A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.
- B. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.
- C. The ICSC must have their own operating UL listed panel fabrication facility. All panels must be fabricated at this facility and meet all UL 508/508A requirements.
- D. ICSC:

1. Contractor, through the use of a pre-qualified ICSC, is responsible for the implementation of the PCIS and the integration of the system with other required instrumentation, control devices, and software.
 2. The ICSC assumes full responsibility, through the Contractor, to perform all work to select, furnish, install, program, test, calibrate, and place into operation all instrumentation, controls, telemetry equipment, control panels, and control system including application software, for a complete, integrated and functional PCIS system.
 3. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these Specifications that the ICSC be responsible for the integration of the PCIS with existing devices and devices provided under the Contract Documents with the objective of providing a completely integrated control system.
- E. System supplier responsibilities:
1. In accordance with the requirements of the Electrical Specifications.
 2. System supplier:
 - a. Due to the critical and complex technical requirements of this Project, all Work (materials, equipment, products, submittals, labor, services, etc.) specified in the Electrical, and the Instrumentation and Control Specifications, and all Work indicated on the Electrical and Instrumentation Drawings is to be furnished by a single system supplier who has single source responsibility for both the process control and instrumentation systems and the electrical power system.
 3. Contractual relationship:
 - a. Form a contractual relationship between the electrical subcontractor and the ICSC.
 - b. Requirements for the first tier subcontractor:
 - 1) Contract directly with the Contractor.
 - 2) Be either the electrical subcontractor or the ICSC.
 - c. Requirements for the second tier subcontractor:
 - 1) A division of the first tier subcontractor, or
 - 2) A joint venture with the first tier subcontractor, or
 - 3) A subcontractor to the first tier subcontractor.
 - d. The system supplier manages, directs, and supervises all of the Work of its second tier subcontractor. The system supplier is solely responsible for the entire electrical and instrumentation system including, but not limited to, all Electrical, Instrumentation, and Process Contract Drawings, the Instrumentation and Control and the Electrical Specifications:
 - 1) Provide any additional conduit, wire, etc.
 - 2) Any additional I/O, programming, screens, interface devices needed by the system supplier are to be provided by the electrical subcontractor or the ICSC, under the above outlined working agreement.
 - 3) Ensure compatibility between the PCIS system and the electrical system being installed.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in the Contract Documents and this Section.

- B. Store all equipment and materials delivered to the job site in a location that will not interfere with the construction or the Owner's operations.
- C. Shipping precautions:
 - 1. After completion of shop assembly, successful Source Test, pack all equipment, cabinets, panels, and consoles in protective crates and enclose in heavy-duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
 - 2. Place dehumidifiers when required, inside the polyethylene coverings.
 - 3. Skid-mount the equipment for final transport.
 - 4. Provide lifting rings for moving without removing protective covering.
 - 5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.
- D. Special instructions:
 - 1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.
- E. Tagging:
 - 1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
 - 2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCS.
 - 3. Tag instruments immediately upon receipt in the field.
 - 4. Prominently display identification on the outside of the package.
 - 5. Utilize the Tag and Loop Number identifications shown on the P&IDs.
- F. Delivery and inspection:
 - 1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

1.08 PROJECT OR SITE CONDITIONS

- A. Site conditions:
 - 1. Provide a PCS, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
 - 2. Seismic classification:
 - a. Provide all equipment and construction techniques suitable for the seismic requirements for the site.
 - 3. Wind:
 - a. Provide all equipment and construction techniques suitable for the site wind loading criteria.
 - 4. Altitude, temperature and humidity:
 - a. As specified in the Contract Documents.
 - b. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.
 - c. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors

subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer's guidelines:

- 1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not indicated on the Drawings.
5. Area classifications:
 - a. Furnish enclosures that meet the requirements outlined in NEMA Standard 250:
 - 1) NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
 - 2) NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.
 - 3) NEMA Type 4X: Made from corrosion resistant materials and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion. Provide specific materials as specified or indicated on the Drawings.
 - 4) NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.
 - 5) NEMA Type 6: Rated for submergence.
 - 6) NEMA Type 6P: Rated for prolonged submergence.
 - 7) NEMA Type 7: Intended for installation in locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2) meeting the requirements outlined in Section 16052 - Hazardous Classified Area Construction.
 - 8) NEMA Type 8: Intended for installation in either indoor or outdoor locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2) and the equipment is oil-immersed.
 - 9) NEMA Type 9: Intended for installation in locations where explosive or combustible dust may be present (Class II Division 1 or Class II Division 2).
6. Site security:
 - a. Abide by all security and safety rules concerning the Work on the Site, as specified in the Contract Documents.

1.09 SEQUENCING

- A. General:
 1. As specified in –the Contract Documents.
 2. Testing requirements are specified in the Contract Documents and 17950 - Commissioning for Instrumentation and Controls.
 3. General scheduling requirements are specified in the Contract Documents.
 4. Work restrictions and other scheduling requirements are specified in the Contract Documents.
 5. Commissioning requirements as specified in the Contract Documents.

- B. Pre-submittal conferences:
 - 1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire project, equipment, control philosophy, schedules, and submittal requirements.
 - 2. The Contractor, instrumentation and control subcontractor, electrical subcontractor, and all manufacturers furnishing major pieces of equipment must attend, including but not limited to:
 - a. Vendor control panels.
 - b. Chemical feed systems.
 - c. Motor control centers.
 - d. Switchgear.
 - e. Variable frequency drives.
 - f. Lighting.
 - g. Engine generators.
- C. System configuration meetings:
 - 1. Review the system configuration, the HMI system database, control schemes, displays, report formats, etc. with the Engineer and Owner on at least 3 occasions during development:
 - a. Preliminary meeting: Before configuration work is begun. The ICSC must bring to this meeting example of displays, display symbols, reports, etc. to show the capabilities of the system software.
 - b. Intermediate review meeting: Held after the initial database is entered and typical screens and reports have been entered.
 - c. Presubmittal review meeting: Submit an informal hardcopy of developed HMI screens for review by the Engineer to determine that requirements are being sufficiently met.
 - d. Final review meeting: Held after initial completion of all configuration work. This final meeting may not be held in conjunction with the Source Test. Make final format revisions after this review.
 - 2. Additional requirements as specified in Sections 17100 - Control Strategies and 17720 - Control Systems: Programmable Logic Controllers
- D. Control logic meetings
 - 1. Review the PLC programming with the Programmer, Engineer, and Owner on at least 3 occasions during development. Individuals responsible for programming PLCs and other programmable devices supplied by Contractor shall attend this meeting by telephone conference call.
 - a. Preliminary meeting: Meet before configuration work is begun on any PLCs programmed by the Contractor (including those provided through subcontractors and suppliers).
 - 1) Contractor shall provide a list of each PLC and other programmable devices that will interface to the rest of the control system, including make, model, and a description of the interface; provide contact information for each individual responsible for programming each said PLC and device; and provide a listing of the submittals that will contain HMI/LOI interface information with a schedule for when each submittal will be provided.
 - b. Intermediate review meeting: Held after approximately one-half of the interface submittals identified in the Pre-submittal Conferences paragraph above have been submitted.

- 1) Individuals responsible for programming PLCs and other programmable devices supplied by Contractor shall attend this meeting.
 - 2) Meet to discuss all control system interface submittals and their requirements.
 - c. Final review meeting: Held after all HMI/LOI interface submittals have been submitted.
 - 1) Meet to discuss HMI/LOI interface submittals and requirements.
 2. Vendor Equipment Meetings: Facilitate a meeting with each equipment supplier (including HVAC) who is providing equipment with a PLC and/or LOI. Meeting discussion point will include the following at a minimum:
 - a. Tag Naming Conventions.
 - b. PLC to PLC global data mapping.
 - c. All PLCs to HMI tags mapping.
 - d. LOI screen colors and navigation.
 - e. Interlock and Permissive definitions.
 - f. Communication Methods.
 - g. Standard code blocks for common control functionality.
 - h. Alarms: Clearing, formats, colors, and status.
 3. Additional requirements as specified in Sections 17100 - Control Strategies, 17101 - Specific Control Strategies, 17720 - Control Systems: Programmable Logic Controllers.
- E. Source testing:
1. Before the delivery and installation of the PCS system to the job site, but after the procurement, assembly, and configuration of all components, perform the Source Test.
 2. Schedule the Source Test after receiving approval of the Source Test procedures submittal.
 3. Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
 4. Notify the Engineer of scheduled tests a minimum of 15 days before the date of the test.
- F. General Field Start-Up and testing procedures:
1. As specified in the Contract Documents.
- G. Installation testing:
1. As specified in the Contract Documents.
 2. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
 3. Acceptance of the PCIS Installation testing must be provided in writing by the Owner before the performance testing may begin.
- H. Training:
1. As specified in the Contract Documents.
- I. Functional testing:
1. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.

2. Loop validation test.
 3. As specified in Section 17950 - Commissioning for Instrumentation and Controls.
 - a. Notify the Owner of scheduled tests a minimum of 21 days before the estimated completion date of installation and wiring of the PCIS.
 - b. Complete loop validation testing a minimum of 5 days before the pre-commissioning phase of the project.
 - c. Loop validation certifications:
 - 1) After the field device loop tests have been successfully completed as specified in Section 17950 - Commissioning for Instrumentation and Controls for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, Vendor, and the Owner's representative with test data entered, together with a clear and unequivocal statement that all instrumentation, including all control and signal wiring, has been successfully calibrated, inspected, and tested.
 - a) Acceptance of the PCIS Installation Testing must be provided in writing by the Engineer before the Process Operational Period may begin.
- J. Provide all special tools and spare parts, as specified in the Maintenance paragraph of this Section, before Process Operational Period commences, suitably wrapped, and identified.
- K. Process Operational Period:
1. Upon completion of the Process Operational Period, conduct an Instrumentation and Controls Process Performance Test as a condition for Project final completion.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. Provide additional warranty as specified in the individual Instrumentation and Control Specifications that extends beyond the Correction Period, as specified in the General Conditions.

1.12 SYSTEM PROCESS START-UP

- A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

- A. Before Substantial Completion, perform all maintenance activities required by the Contract Documents including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
- B. Furnish all spare parts as required by the Contract Documents.
- C. Spare parts:
 - 1. Furnish the spare parts selected by the Engineer from the priced list of spare parts in the hardware submittal.
 - 2. Furnish a price list of all special tools required to calibrate and maintain all of the instrumentation provided under the Contract Documents. Furnish the special tools selected by the Engineer from the priced list.
- D. Provide additional spare parts specified in other sections of the Instrumentation and Control Specifications.
- E. Submit all special tools and spare parts, suitably wrapped and identified, before Process Operational Period commences.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Provide similar items from a single manufacturer throughout the PCIS portion of the Project.
- B. Allowable manufacturers are specified in individual instrument and equipment specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these devices and that bear all approvals and labels as required by the Specifications.
- B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise specified to match existing equipment.
- B. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.
- C. Signal transmission:
 - 1. Analog signals:
 - a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
 - b. Furnish electrical analog signals outside control panels that are 4 to 20 milliamperes 24 VDC, except as indicated.
 - c. Analog signals within enclosures may be 1 to 5 VDC.
 - d. Electrically or optically isolate all analog signals from other signals.
 - e. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
 - f. Maintain the total 4 to 20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
 - g. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
 - 2. Pneumatic signals:
 - a. All pneumatic signals: 3 to 15 pounds per square inch gauge.
 - 3. Discrete input signals:
 - a. As indicated in the controller hardware specification.
 - 4. Discrete output signals:
 - a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
 - b. Provide external terminal block mounted fuse with blown fuse indication for all discrete outputs.
 - c. Provide interposing relays for all discrete outputs for voltage and/or current compatibilities.
 - d. Provide interposing relays as required for functionality of the control circuit.
 - 5. Signal performance and design criteria:
 - a. Stability:
 - 1) After Controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
 - b. Response:
 - 1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.
 - c. Agreement:
 - 1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.

- d. Repeatability:
 - 1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
 - e. Sensitivity:
 - 1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.
 - f. Performance:
 - 1) All instruments and control devices shall perform in accordance with the manufacturers' specifications.
- D. Discrete circuit configuration:
- 1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
 - 2. Alarm contacts: Fail to the alarm condition.
 - 3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.
- E. Grounding:
- 1. Provide control panels with a signal ground bus, isolated from the power ground bus:
 - a. Provide multiple panels in one location with a common point for signal ground bus connection to ground.
 - 2. Ground single-point ground shields and measurement loops at the source panel external terminals, unless otherwise noted, by bonding to the control panel signal ground bus.
 - 3. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.
- F. Instrument air:
- 1. Where indicated on the Drawings, provide dry, filtered control air at 30 pounds per square inch gauge nominal pressure piped to all field instruments and instrument panels requiring air:
 - a. Provide each field instrument with an integral, non-adjustable filter/regulator assembly to provide regulated air.
 - b. Provide each instrument panel requiring air with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments.
 - c. Filter all air to 5-micron maximum particle size.
 - d. Provide low pressure switch to alarm on insufficient air supply.

2.07 ACCESSORIES

- A. Provide flow conditioning devices or other required accessories if necessary to meet the accuracy requirements in the Contract Documents.
- B. Nameplates:
 - 1. Provide a nameplate for each controller, instrument transducer, instrument power supply, solenoid, or any other control device located either in the field or within panels.

2. All nameplates shall be of identical style, color, and material throughout the facility.
3. Device nameplates shall include:
 - a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
 - 1) Device tag and loop number ID (e.g., FIT-60.011).
 - 2) PLC ID (e.g., PLC-11).
 - 3) Power information (e.g., PCM-11, 120VAC).
 - b. White lettering on a black background, laminated plastic.
4. All instruments shall be equipped with Type 316 stainless steel nameplate with the instrument tag stamped in 3/8-inch letters and connected to the instrument using Type 316 stainless steel wire.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products that bear all approvals and labels as required by the Specifications.
- B. Arrange with all manufacturers of the equipment and fabricators of panels and cabinets, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
 1. Equipment includes the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices.
- C. Source Test is specified in Section 17950 - Commissioning for Instrumentation and Controls.

PART 3 EXECUTION

3.01 EXAMINATION

- A. The ICSC is encouraged to visit the site and examine the premises completely before bidding. It is the ICSC's responsibility to be fully familiar with the existing conditions and local requirements and regulations.
- B. Review the existing Site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.
- C. Provide a complete instrumentation and control system:
 1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, and process control and instrumentation system.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Equipment locations indicated on the Drawings may change due to variations in equipment size or minor changes made by others during construction:
 - 1. Verify all dimensions as indicated on the Drawings:
 - a. Actual field conditions govern all final installed locations, distances, and levels.
 - 2. Review all information indicated on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
 - 3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
- B. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.
- C. The PCIS configurations are diagrammatic:
 - 1. The locations of equipment are approximate unless dimensioned.
 - 2. Where Project conditions require, make reasonable changes in locations and arrangements.
- D. Field instruments installation:
 - 1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer's instructions.
 - 2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
 - a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
 - b. Provide sun shields for all field electronic instruments exposed to direct sunlight.
 - 3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
 - a. Type of flexible conduit required for the area classification:
 - 1) Area classification as specified in this Section.
 - b. Maximum length of 18 inches.
 - 4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
 - a. Special cable applications shall be in accordance with the NEC.
 - 5. Verify the correctness of each installation:
 - a. Polarity of electric power and signal connections.
 - 6. Ensure all process connections are free of leaks.
- E. Process sensing lines and air tubing:
 - 1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
 - 2. Provide supports for rigid tubing at intervals of not more than 3 feet.
 - 3. Slope horizontal runs of instrument tubing at a minimum of 1/16-inch per foot to allow for draining of any condensate.
 - 4. Bends:

- a. Use proper tool.
 - b. Make bends for parallel lines symmetrical.
 - c. Make bends without deforming or thinning the walls of the tubing.
- 5. Square-cut and clean all ends of tubing before being inserted in the fittings.
- 6. Provide bulkhead fittings at all panels requiring pipe and/or tubing entries.
- 7. Use stainless steel tubing for all piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
 - a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.
- F. Conduit, cables, and field wiring:
 - 1. Provide all PCS equipment cables, and process LAN communication networks under the Instrumentation and Control Specifications.
 - 2. Provide terminations and wire identification as specified in the Electrical Specifications.
 - 3. Protect all wiring from sharp edges and corners.
 - 4. Provide all conduits, fittings, boxes, etc. in accordance with all the requirements of the Electrical Specifications.
- G. Equipment tie-downs:
 - 1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the Site.
 - 2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.
- H. Existing instrumentation:
 - 1. Clean, recondition and re-calibrate each existing instrument to be reused, removed, or reinstalled using an authorized service facility of the instrument manufacturer.
 - 2. Provide certification of this Work before reinstallation of each instrument.
- I. Instrument tagging:
 - 1. As specified in Section 16075 - Identification for Electrical Systems.
 - 2. Provide all field-mounted instruments with nameplates:
 - a. Nameplates engraved with the instrument's full tag number as indicated on the Drawings:
 - 1) Affix tags with stainless steel wire fasteners.
 - 3. Provide all back of panel instruments with nameplates:
 - a. Engraved with the instrument's full tag number as indicated on the Drawings:
 - 4. Provide all front of panel instruments with a nameplate:
 - a. Engraving to include the following:
 - 1) Instrument's full tag number.
 - 2) Service description.
 - b. Nameplates:
 - 1) Secure nameplates to the panel with stainless steel screws.
 - 2) Use an accepted adhesive if screws would violate the NEMA or other ratings of the enclosure.
- J. Cable and conductor termination:

1. Terminate all cables and conductors on terminal blocks.
 2. Terminal block enclosures:
 - a. Suitable for the area classification as specified in this Section.
- K. Surge protection:
1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments and the panel.
 2. Individually fuse each 4 to 20 milliamperes direct current loop with a 1/16 ampere fuse between power supplies and receiver surge protectors.
 3. Provide voltage surge protection for 4 wire transmitters and analyzers:
 - a. Protect both power source and signal loop.
- L. Scope and responsibilities:
1. Refer to the following table for procurement and installation scope and responsibilities for the owner, design engineer, contractor, integrator, and programmer.

Item No.	Task	Responsible Parties					Service or Equipment Supplied By
		Owner (O)	Design Engineer	Contractor (C)	Integrator (I)	Programmer (P)	
1.00	I&C Design Update						
1.01	Owner furnished equipment procurement.	L	A				O
1.02	Equipment and package system procurement.			L			C
1.03	Equipment and package system submittal preparation.			L			C
1.04	Equipment and package system submittal review.	A	L				DE/ O
1.05	Update I&C design to incorporate any changes, if changes approved by Owner during the submittal processes, for equipment and/or package systems.	A	L		A		DE
2.00	HMI Application Programming						
2.01	HMI software application programming.	A		A	A	L	P
2.02	Develop PLC/DCS interfaces to Vendor package systems (Vendor package system programmed by Vendor).	A		A	A	L	P
2.03	Digital field network interface and network configuration (ownership including calibration and setup).	A		A	A	L	P

Item No.	Task	Responsible Parties					Service or Equipment Supplied By
		Owner (O)	Design Engineer	Contractor (C)	Integrator (I)	Programmer (P)	
2.04	HMI Graphical User Interface.	A		A	A	L	P
3.00	Vendor Package and Auxiliary System Application Programming						
3.01	Vendor Package PLC software application programming (procured by Contractor).			A	L		I
3.02	Configuration of auxiliary systems necessary to provide required functionality and connectivity for monitoring and control of auxiliary systems: HVAC, Power Monitors, Lighting, and Fire Protection.			A	L		I
4.00	Integration						
4.01	Instrumentation specifications and procurement.			A	L		I
4.02	Vendor supplied package and Auxiliary system coordination with plant PLC/DCS (communications, submittals, software development).			A	L	S	I
4.03	Vendor package systems and Auxiliary system interface demonstration at FAT, where required.			S	L	S	I
4.04	Control system equipment, Vendor package system, and Auxiliary system interface submittal review and preparation for formal Owner review.			S	L		I
4.05	I&C Design update to reflect approved vendor submittals (if required).	A	L	S	S		
5.00	Equipment and Panels						
5.01	PLC/DCS Process Control System						
5.02	PLC/DCS control panels and associated panel equipment procurement.			A	L		I
5.03	PLC/DCS panels and associated panel equipment fabrication.			A	L		I
5.04	PLC/DCS panels factory testing.	W	W	A	L	A	I

Item No.	Task	Responsible Parties					Service or Equipment Supplied By
		Owner (O)	Design Engineer	Contractor (C)	Integrator (I)	Programmer (P)	
5.05	PLC/DCS installation.	W		A	L		I
5.06	PLC/DCS field testing OAT, SAT.	W	W	A	L		I
5.07	Operator Interface Stations (both in panel and desktop) related setup and configuration.	W		A	A	L	P
5.08	Field PLC/DCS interfaces (HMIs).			A	L	A	I
5.09	Communications						
5.10	Fiber patch panel procurement and installation.			A	L		I
5.11	Ethernet switch procurement and installation.			A	L		I
5.12	Copper patch panel procurement and installation.			A	L		I
5.13	Uninterruptible power supply procurement and installation.			A	L		I
5.14	Field Local Control Panels (LCPs)						
5.15	LCP procurement and fabrication.			A	L		I
5.16	LCP installation.			A	L		I
5.17	Local Operator Interfaces (LOIs)						
5.18	LCP procurement and fabrication.			A	L		I
5.19	LCP installation.			A	L		I
5.20	LCP programming.			A	A	L	P
5.21	Control Room						
5.22	Workstation furniture procurement and installation.			A	L		I
6.00	Instruments and Control Valves						
6.01	Submittal & Datasheets.			A	L		I

Item No.	Task	Responsible Parties					Service or Equipment Supplied By
		Owner (O)	Design Engineer	Contractor (C)	Integrator (I)	Programmer (P)	
6.02	Procurement.			A	L		I
6.03	Installation.			A	L		I
6.04	Setup and/or Calibration.			A	L		I
7.00	Electrical and Mechanical for Process Control System						
7.01	Building electrical provision and installation - cable / conduit / wire.			A	L		I
7.02	Building mechanical provision and install - including process instruments related tubing			L	A		C
7.03	Building wiring racks and supports (cable and/or conduit) - coordinated w/DIV 16 power contractor where applicable.			L	A		C
7.04	Building internal Fiber Optic backbone conduit installation (from building entrance / duct bank).			A	L		C
7.05	Building internal communication wiring - DeviceNet, Modbus, Ethernet, etc. from PLC/DCS and/or patch panel.			A	L		C
7.06	Electrical and mechanical installation inspection.	W	A	L	A		C
7.07	Vendor Package - On/Off Skid related electrical controls installation.			A	L		I
7.08	Vendor Package - On/Off Skid related mechanical controls installation.			L	A		C
7.09	Vendor Package Electrical and Mechanical installation inspection.	W	A	L	A		C
7.10	Site Fiber Optic backbone cable installation, termination, and certification testing.			A	L		I
7.11	Network testing.	W	A	A	L		I
8.00	Process Start-up						
8.01	Pre-operation and component test.	W	A	A	L	A	I

Item No.	Task	Responsible Parties					Service or Equipment Supplied By
		Owner (O)	Design Engineer	Contractor (C)	Integrator (I)	Programmer (P)	
8.02	Loop checkout.	W	A	A	L	A	I
8.03	System Acceptance Test (SAT).	W	A	A	L	A	I
8.04	Operational Testing.	W	A	A	L	A	I
8.05	Commissioning Testing.	L	A	A	A	A	O
9.00	Process Closeout						
9.01	Redline Drawings and/or Electronic files submit to Owner.			A	L		I
9.02	As-builts (record set) - Update All Drawings.			A	L		I
9.03	Operation and Maintenance Manuals.			A	L		I
9.04	Operational Testing and Commissioning Sign Off Forms.	W	W	A	L		I
9.05	Training.	W		A	L	S	I
9.06	Commissioning (process performance testing).	L	A	A	A	S	O
Key: L – Lead, A – Assist, S – Support, W – Witness							

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in the General Conditions.
- B. Owner Training:
 - 1. Demonstration requirements are specified in Section 17950 - Commissioning for Instrumentation and Controls.
 - 2. General:
 - a. Provide system maintenance and operator training courses for all the instrumentation and control systems furnished.

- b. Provide system maintenance and operator training courses for all the instrumentation and control equipment and systems furnished, as described below.
 - 1) All training described below shall be provided by the Contractor.
 - 2) The Programmer is not responsible for the training described in this Section.
 - 3) The Programmer will provide training on software provided by the Programmer.
- c. Conduct all training at the Project Site unless another location is accepted by the Engineer and Owner:
 - 1) Include instruction on the use of all maintenance equipment and special tools provided under the Contract.
- d. Tailor training classes to the specific needs of the class participants:
 - 1) Develop separate courses for operators, maintenance staff, and supervisors:
 - a) The specific categories and number of personnel in each category are identified below.
 - 2) Furnish training courses that are a combination of classroom and hands-on training:
 - a) To the greatest extent possible, utilize components from the Owner's PCS system.
 - b) Limit classes that include extensive hands-on activities to a maximum of 5 students per class.
 - 3) Coordinate with the Owner on the minimum number of sessions for each course in order to satisfy class size restrictions and limitations scheduling Owner staff.
 - 4) Furnish additional sessions if required to accommodate the total number of personnel identified for each course.
- e. Temporarily install a test PLC and 2 user workstations in the training area for PCIS system training classes conducted on-site:
 - 1) Configure the workstations as full-function operator stations during the training classes.
 - 2) Connect these components with a LAN in order to fully simulate system operation.
- f. Schedule individual training classes:
 - 1) Coordinate with the Owner at least 3 weeks before the start of the class:
 - 2) Schedule training classes Monday - Friday between 7:30 a.m. and 3:30 p.m.
 - 3) Each individual daily training session, travel time excluded:
 - a) Minimum duration of 4 hours.
 - b) Maximum duration of 7 hours.
 - c) Breaks scheduled at least every 90 minutes and 1 hour for lunch.
 - 4) Complete training for maintenance personnel 90 days before Process Operational Period.
 - 5) Complete operator training classes before process start-up of the control system software, or any part of it:
 - a) As specified in the Sequencing article of this Section.
 - 6) Schedule follow-up training classes after the PCS start-up on a schedule determined by the Owner.
- g. Instructor qualifications:

- 1) Highly qualified training instructors for technical training with demonstrated expertise in not only control system functionality but also professional training techniques:
 - a) Instructor qualifications are subject to the approval of the Engineer.
 - 2) Furnish training instructors thoroughly familiar with the PCIS system, who are members of the implementation team.
 - 3) One of the individuals conducting the PCIS training course must be the same individual responsible for the majority of the programming that was performed for the instrumentation and control system.
3. Training manuals and materials:
- a. Furnish training manuals and other materials for training courses.
 - b. Manuals are to be professionally written to present the course material in a format that is easy to comprehend.
 - c. The manuals are to serve as teaching aids during presentation of the training classes.
 - d. Manuals are to serve as reference material after the training has been completed.

3.08 FIELD QUALITY CONTROL

A. Inspection:

1. Allow for inspection of PCIS installation as specified in the Contract Documents.
2. Provide any assistance necessary to support inspection activities.
3. Engineer inspections may include, but are not limited to, the following:
 - a. Inspect equipment and materials for physical damage.
 - b. Inspect installation for compliance with Drawings and Specifications.
 - c. Inspect installation for obstructions and adequate clearances around equipment.
 - d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
 - e. Inspect equipment nameplate data to verify compliance with design requirements.
 - f. Inspect cable terminations.
 - g. Inspect/witness instrument calibrations/verifications.
4. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Commissioning for Instrumentation and Controls.

B. Instrument Installation Inspection:

1. Provide any assistance necessary to support inspection activities.
2. Inspections may include, but are not limited to, the following:
 - a. Inspect equipment and materials for physical damage.
 - b. Inspect the installed arrangement, lay lengths, orientation, piping obstructions, etc., that could affect the instruments accuracy or repeatability.
 - c. Inspect installation for compliance with Drawings and Specifications.
 - d. Inspect installation for obstructions and adequate clearances around equipment.

- e. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
 - f. Inspect equipment nameplate data to verify compliance with design requirements.
 - g. Inspect cable terminations.
 - h. Inspect/witness instrument calibrations/verifications.
 - 3. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Commissioning for Instrumentation and Controls.
 - 4. Field acceptance testing: (Functional Testing) is specified in Section 17950 - Commissioning for Instrumentation and Controls. Additional general requirements are specified in the Contract Documents.
- C. Installation supervision:
- 1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the ICSC shall provide the following services:
 - a. Installation resources:
 - 1) Coordinate with the Contractor regarding installation requirements of the Contract Documents.
 - b. Provide technical assistance to installation personnel by telephone:
 - 1) Furnish installation personnel with at least 1 copy of the accepted submittals, including all installation details.
 - c. Periodic inspections during the construction period.
 - d. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
 - e. Field verify accuracy and calibration of all instruments.

3.09 ADJUSTING

- A. Control valves:
 - 1. Stroke all control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
 - 2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.
- B. Make all revisions necessary to the control system software, as directed by the Engineer.
 - 1. It is understood that the Contractor knows and agrees that changes will be required in the control system software during the Source Testing, Functional Testing, Process Operational Period, Process Start-Up, and during the Project Correction Period.

3.10 CLEANING

- A. As specified in Section the Contract Documents.
- B. Vacuum clean all control panels and enclosures before process start-up and again after final completion of the project.
- C. Clean all panel surfaces.

- D. Return to new condition any scratches and/or defects.
- E. Wipe all instrument faces and enclosures clean.
- F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
 - 1. Neatly coil and label all spare wiring lengths.
 - 2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.

3.11 PROTECTION

- A. Protect all Work from damage or degradation until date of Substantial Completion.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17051

PREQUALIFICATION OF INSTRUMENTATION AND CONTROL SYSTEM CONTRACTOR

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Prequalification as an instrumentation and control system subcontractor (ICSC).
- B. Additional requirements for the ICSC and the system supplier are specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES (NOT USED)

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems and other sections of the Contract Documents.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS (NOT USED)

1.06 QUALITY ASSURANCE

- A. Responsibilities:
 - 1. The Contractor, through the use of a qualified system supplier and qualified ICSC, electrical contractor, and mechanical installers, shall be responsible to the Owner for the implementation of the complete process control and instrumentation system, including the integration of the PCIS system and other instrumentation and control devices provided by the ICSC with other required control panels, instrumentation, and other control devices provided under other sections of the Contract Documents.
 - 2. System supplier: Due to the critical and complex technical requirements of this Project, all the systems specified in the Electrical and the Instrumentation and Control Specifications shall be the responsibility of a single system supplier company, who shall have single source responsibility for the process control and instrumentation systems and the electrical power system.
 - 3. A contractual relationship shall exist between the electrical contractor and the ICSC. The first tier contractor shall contract directly with the Contractor. The first tier contractor shall be either the electrical contractor or the ICSC, and shall be defined as the system supplier. The second tier contractor shall be either a division of, a joint venture, or a subcontractor to the first tier contractor.

4. The system supplier shall manage, direct, and supervise the Work of its second tier contractor. As such, the system supplier, shall be responsible for the entire electrical, instrumentation, and control system, including, but not limited to, all Work indicated on the Electrical and Instrumentation Contract Drawings, or specified in the Instrumentation and Control and Electrical Specifications.
5. ICSC responsibilities:
 - a. The ICSC shall perform the following Work with its own employees, as a minimum:
 - 1) Perform all Work specified in the Instrumentation and Control Specification and Work indicated on the Instrumentation Drawings, except where the Work is clearly specified to be provided under other specifications of the Contract Documents.
 - 2) Prepare hardware submittals for the PCIS system.
 - 3) Design, develop, and draft designs for all control panels indicated in the Instrumentation Drawings.
 - 4) Fabricate panels.
 - 5) Design, develop, and draft all loop drawings, except those provided by vendors of equipment packages specified in other sections of the Contract Documents.
 - 6) Develop all requisite loop drawings and record loop drawings associated with equipment provided by the Owner and existing equipment.
 - 7) Prepare the test plan, the training plan, and the spare parts submittals for all Instrumentation and Control Work.
 - 8) Procure all PCIS system hardware.
 - 9) Perform all programming and configuration of the PCIS system, except for PLCs provided by equipment vendors.
 - 10) Perform factory tests on panels.
 - 11) Oversee and certify the installation of the PCIS system and the instrumentation and control system.
 - 12) Oversee, document, and certify loop testing.
 - 13) Oversee, document, and certify system pre-commissioning.
 - 14) Conduct the site acceptance tests for the PCIS.
 - 15) Prepare technical manuals.
 - 16) Conduct training.
 - 17) Prepare record drawings.
 - 18) Integrate the PCIS with instrumentation and control devices being provided by equipment vendors and otherwise provided under other sections of the Contract Documents:
 - a) Develop requisite loop drawings and record loop drawings associated with equipment provided under other sections of these Specifications.
 - b) Resolve signal, power, or functional incompatibilities between the PCIS and interfacing devices. Coordinate communication interface including addressing, data transfer, register identification, and hardware connections.
 - b. Any ICSC responsibilities in addition to the list above are at the discretion of the Contractor.

1.07 PREQUALIFICATION REQUIREMENTS

A. General:

1. Firms interested in submitting bids as the ICSC as described above and as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems must submit a prequalification submittal in accordance with this Section.
2. Only those firms who, based on their prequalification submittals and related investigations, meet the minimum requirements defined in this Section under "Prequalification Minimum Requirements" below, who are approved by the Owner, and are identified by addendum to the Contract Documents, shall be eligible to submit bids as the ICSC for this Project.
3. Prequalification of prospective ICSC bidders will be determined by the application of a pre-established pass/fail rating system to the information submitted by prospective bidders, supplemented by additional investigation by the Owner or Engineer.

B. Submittal requirements:

1. Prequalification submittals shall be delivered to the Owner.
2. Prequalification submittals shall be delivered in a sealed envelope or box, clearly addressed, and clearly labeled: "PREQUALIFICATION SUBMITTAL, INSTRUMENTATION AND CONTROL SYSTEM Contractor.
3. Submit 4 copies of the prequalification submittal. Clearly identify which copy contains original signatures.

C. Prequalification submittal shall include the following information organized in the order outlined below:

1. General information on the proposing company:
 - a. Document that the ICSC's company has been actively involved in the instrumentation, PLC based control systems, and process control systems business for a number of years and has adequate facilities, organization structure, manpower and technical and managerial expertise to properly perform the Work as specified in these Specifications.
 - b. Submit a financial prospectus indicative of the corporation's financial state. This prospectus shall also include:
 - 1) A letter from a financial institution indicating a current line of credit and bonding limit which can be applied to this Project.
 - 2) Latest annual report or reviewed financial statement.
2. Document that the ICSC has a qualified permanent service facility:
 - a. Said facility shall be staffed with permanent employees and equipped with the tools and test equipment necessary to calibrate, test, and start-up all of the instrumentation, control, telemetry, and PCS systems hardware and software furnished under this Contract, including remote diagnostic capability.
 - b. Document in-house resource of permanent personnel experienced in the design and programming of equipment and systems as required by these Specifications.

- c. Document the existence of a training program staffed by qualified instructors, to provide proper training in the operation and maintenance of equipment as specified in these Specifications.
 - d. Document in-house computer application software development capability.
 - e. Document that the firm is a recognized or certified "system integrator partner" or similar designation for the PCS software and PLC system being supplied for this Project.
- 3. Similar project experience of the company:
 - a. Provide a list of at least 3 successfully completed projects for a water and/or wastewater system of similar scope and complexity in which the proposing firm used components the same as those intended for use on this Project. The proposing firm must have performed, for each listed project, system engineering, system fabrication and installation, documentation (including schematic, wiring and panel assembly drawings), software configuration and documentation, field-testing, calibration and start-up, operator instruction and maintenance training. In addition, provide the following information for each project:
 - 1) Name of plant or system owner, contact name, and current telephone number. Design engineer's name, address, and telephone number. Failure to provide current contact information may result in the listed project being disqualified for use in meeting the minimum requirements for prequalification.
 - 2) Manufacturer and model number(s) of the PLC based control system and the computer-based PCS system used for both hardware and software.
 - 3) Brief description of the system.
 - 4) Approximate number of input and output signals: analog and digital.
 - 5) Brief application software description.
 - 6) Contracted cost of the system, including change orders for the completed projects.
 - 7) Duration of the project and date of completion.
- 4. Information on the proposed project team members:
 - a. Provide the name and resume of the individual persons who will be responsible for each of the following:
 - 1) Office engineering and management of this Project.
 - 2) Lead for software configuration/programming.
 - 3) Individual who will be responsible for the hardware and hardware interface design.
 - 4) Individual who will be responsible for field-testing, calibration, and start-up.
 - 5) Individual who will be responsible for operator training.
 - b. All of these individuals must be permanent employees of the proposing firm.
- 5. Information on the PCS system to be supplied:
 - a. A proposed system block diagram detailing the system configuration.
 - b. Description and specifications of the major equipment components to be furnished for the PCS system. Include the following as a minimum:
 - 1) PCs.

- 2) PLCs.
- 3) CPUs.
- 4) RTUs.
- 5) Printers.
- 6) CRTs.
- 7) Servers.
- 8) Network equipment.
- 9) Modems.
- 10) Radios.
- 11) Any other electrical or electronic equipment costing more than \$5,000.
- c. A brief description of the proposed PCS software's features.
- d. Supporting descriptive information, calculations, etc., to facilitate a complete evaluation of the prequalification submittal.
- e. A clear statement on a separate page that the proposed system is as specified in the Specifications in terms of performance, reliability, and manufacturer's support.
6. Certification of scope of supply:
 - a. Provide a clear description of the proposed (minimum) scope of supply for the proposing ICSC firm. This scope description shall be binding and shall be considered the minimum scope of work for the proposing firm. The intent is to verify that proposing firms can and will perform the complete, minimum scope of the ICSC described above and as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems. Additions to this minimum scope of supply are allowed if they do not violate other requirements of the Contract Documents.
 - b. Execute and submit a written certification of intent to assume full responsibility for the complete requirements of the Instrumentation and Control Specifications and related Instrumentation Drawings.
 - c. The certification shall be typed on the firm's letterhead and signed by an authorized representative of the firm.
7. It is the responsibility of the submitting firm to furnish sufficient information of each item in its prequalification submittal to document compliance with the minimum requirements. Failure to submit a complete prequalification submittal shall result in disqualification.
8. If it is discovered at any time that any significant information in a prequalification submittal is incorrect, substantially misleading, or fraudulent, the submitting firm shall be subject to immediate disqualification from participation in the Project.
- D. Prequalification minimum requirements:
 1. To be prequalified to bid on the Project as an ICSC, a proposing company must submit all required information and must meet the minimum requirements set forth in the following list based on the information submitted. For joint ventures, both firms must separately meet the requirements.
 2. The prequalification submittal must be clear, well organized, and complete, and it must provide sufficient information to allow reviewers to determine that the proposing firm meets all minimum requirements. Submittals that are

unclear, poorly organized, or incomplete, may be rejected solely on this basis, and no resubmittal will be allowed.

3. Firm has been in business at least 5 years.
4. Firm has been performing PCS system integration services for at least 5 years.
5. Firm has been supplying PCS systems to the water and wastewater industries for at least 3 years.
6. Firm must have an I&C business volume of at least \$3.0 million, annually.
7. Firm and officers do not have adverse criminal or legal records, such as criminal convictions, defaults, loss of licenses, etc.
8. Firm does not have a poor project performance record, such as repeated claims, litigation, defaults, etc.
9. Firm demonstrates completion of at least 3 similar (water or wastewater) projects in the past 5 years. Each similar project must include:
 - a. Project PCS system cost of at least 1/2 of this Project estimated cost.
 - b. Number of new physical IO points at least 75 percent of the new physical IO count of this Project.
 - c. Same PLC hardware or PCS software as this Project.
 - d. Water or wastewater facility.
 - e. At least 2/3 the number of PLCs as the current project (with CPUs), or greater.
 - f. At least 2/3 the number of operator stations as the current project, or greater.
 - g. "Completion" means the similar project has been installed and is substantially complete.
10. Firm must have their own operating UL listed panel fabrication facility.
11. Proposed personnel have adequate experience and credentials, including:
 - a. PM and PE have served in similar roles on at least 1 comparable project(s) in the past 5 years.
 - b. Lead programmer has a minimum of 5 years of experience on similar projects.
 - c. Firm has an in-state registered electrical or control system engineer who will be an active and significant member of the project team and who will stamp all drawings produced by the firm for this Project.
12. Firm cannot be in bankruptcy.
13. The financial condition of the firm cannot be such that its financial ability to complete the Project is, in the opinion of the Owner, in doubt.
14. Firm must have a minimum of 20 permanent, full-time technical employees, all of whom must be regularly engaged in I&C/PCS design and implementation work.
15. Firm must have a permanent local office within 200 miles of the Project Site that is staffed with at least 5 technical employees (administrative staff does not count), and has been so staffed for the past 12 months.
16. The proposed equipment, software, and systems must comply with the requirements of the Drawings and Specifications. Note however that, prequalification of a proposing firm does not in any way constitute a review or acceptance of any design, equipment, software, device, or system included in the prequalification submittal. Further, the prequalification submittal shall not

be considered to fulfill any contract submittal requirement, except for prequalification under this Section.

E. Submittal evaluation:

1. A committee consisting of members of Owner's staff, Engineer and other consultants selected by Owner will evaluate the completed questionnaires. Engineer and Owner will determine and identify the qualified bidders in accordance with the following timetable. Written notification of this determination will be sent to each bidder.
2. The Owner and Engineer reserve the right to reject any or all prequalification submittals and to waive any irregularities in any submittal.
3. The Owner reserves the right to relax the minimum requirements, in any way deemed to be in the best interest of the Owner, if, in the Owner's opinion, an insufficient number of firms can prequalify under the criteria specified above.
4. Submittals that are incomplete, disorganized, difficult to read, or non-compliant with the content and format requirements set forth in this Section shall be, at the Owner's sole discretion, summarily rejected, and the submitting firm shall be prohibited from bidding on the project as the ICSC.
5. No resubmittals or supplementary information shall be accepted after the submission deadline, unless requested by the Owner.
6. The Owner's decision shall be final as to the acceptability of the proposing ICSC firm. The Owner shall decide acceptability or un-acceptability, and not offer or be required to provide any supporting statements or documentation concerning the decision. The decision of "not prequalified" for a proposing ICSC firm has no implied connotations and only states simply that the proposing ICSC firm has failed to meet the submission or minimum requirements for this particular project.

F. All information submitted for prequalification evaluation will be considered official information acquired in confidence and the Owner and Engineer will maintain its confidentiality to the extent permitted by law.

G. Notification of prequalification:

1. Each applicant will be notified as to its approval or disapproval for prequalification approximately 15 days before acceptance of bids for the complete facility project specified in the Contract Documents.
2. Notification of prequalified ICSC will be made in the form of an addendum to all plan holders, issued during the bidding phase of the project.

H. The project team members identified in the prequalification submittal shall perform the roles described in the submittal, and not be substituted without the written permission of the Owner. Substitute personnel shall be subject to the review and approval of the Engineer, even in cases where the individuals named in the prequalification submittal are no longer employed by the proposing company at the time of contract award.

I. The major equipment components which are identified during this prequalification process shall not be changed without the written approval of the Engineer.

- J. Approval for prequalification as an ICSC shall not be construed as approval of any design or equipment in the prequalification submittal. The Contractor and the ICSC shall be obligated to comply with all requirements of the Contract Documents, regardless of any information included in the prequalification submittal.
- K. Prequalification of a firm as an ICSC shall not be construed as an opinion by the Owner or Engineer that the prequalified firm is qualified to perform the subject work, or that any designs, equipment, software or other items described in the submittal are acceptable or meet the requirements of the Contract Documents. The review of prequalification submittals is solely for the purpose of determining, in the opinion of the Owner and Engineer, if interested firms meet the requirements for prequalification described above.
- L. Prospective bidders desiring to be prequalified are hereby reminded that they will be subject to, and must fully comply with, all of the requirements of the Bidding Documents.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.10 SEQUENCING (NOT USED)

1.11 SCHEDULING (NOT USED)

1.12 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.13 SYSTEM START-UP (NOT USED)

1.14 OWNER'S INSTRUCTIONS (NOT USED)

1.15 COMMISSIONING (NOT USED)

1.16 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

- 2.03 MATERIALS (NOT USED)**
- 2.04 MANUFACTURED UNITS (NOT USED)**
- 2.05 EQUIPMENT (NOT USED)**
- 2.06 COMPONENTS (NOT USED)**
- 2.07 ACCESSORIES (NOT USED)**
- 2.08 MIXES (NOT USED)**
- 2.09 FABRICATION (NOT USED)**
- 2.10 FINISHES (NOT USED)**
- 2.11 SOURCE QUALITY CONTROL (NOT USED)**

PART 3 EXECUTION

- 3.01 EXAMINATION (NOT USED)**
- 3.02 PREPARATION (NOT USED)**
- 3.03 INSTALLATION**
 - A. As specified in 17050 - Common Work Results for Process Control and Instrumentation Systems.
- 3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)**
- 3.05 REPAIR/RESTORATION (NOT USED)**
- 3.06 RE-INSTALLATION (NOT USED)**
- 3.07 FIELD QUALITY CONTROL**
 - A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- 3.08 ADJUSTING (NOT USED)**
- 3.09 CLEANING**
 - A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.11 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.12 SCHEDULES

- A. Example ICSC evaluation criteria form:
 - 1. Example ICSC evaluation criteria form is attached at the end of this Section. This is included as a reference.
 - 2. The example ICSC evaluation criteria form does not overrule any requirements of the specification above.

END OF SECTION

INSTRUMENTATION AND CONTROL SYSTEM CONTRACTOR EVALUATION CRITERIA	Contractor:	Contractor:	Contractor:
Submitted Prequalification Package on Time?			
Basic Criteria per 1.07.C			
1. General Information on the proposing company			
a. Actively involved in PLC/PCS controls industry?			
b. Financial prospectus provided?			
1) Letter from financial institution provided?			
2) Latest annual financial report provided?			
2. Qualified permanent service facility			
a. Sufficient staff and equipment at service facility?			
b. Personnel experienced in systems required for this project?			
c. Training program in place?			
d. In-house application software development capability?			
e. System integrator certification for systems required for this project?			
3. Similar project experience of the company			
a. List of 3 successfully completed projects provided? (See references below)			
4. Information on the proposed project team members			
a. Names and resumes for project team members			
1) Office engineering and management			

INSTRUMENTATION AND CONTROL SYSTEM CONTRACTOR EVALUATION CRITERIA	Contractor:	Contractor:	Contractor:
2) Software configuration/programming lead			
3) Hardware interface designer			
4) Individual responsible for field testing, calibration, and start-up			
5) Individual responsible for operator training			
5. Information on PCS system			
a. Proposed system block diagram provided?			
b. Description and specifications for major PCS system components?			
c. Description of PCS software features provided?			
d. Supporting information provided?			
e. Statement of compliance with specifications provided?			
6. Certification of scope of supply provided?			
Prequalification Minimum Requirements per 1.07.D			
1. Firm has been in business at least 5 years			
2. Firm has been performing process control system work for at least 5 years			
3. Firm has been supplying process control system for water/wastewater for at least 5 years			
4. Firm has I&C business volume of at least \$[3.0 million annually			
5. Firm and officers do not have adverse criminal or legal records			
6. Firm does not have repeated claims, litigation, defaults, etc.			

INSTRUMENTATION AND CONTROL SYSTEM CONTRACTOR EVALUATION CRITERIA	Contractor:	Contractor:	Contractor:
7. Firm has completed at least 3 similar water/wastewater projects in past 5 years			
(See references below)			
8. Firm has its own operating UL listed panel fabrication facility			
9. Proposed personnel have adequate experience and credentials			
a. PM and PE served in similar roles on at least 1 comparable project			
b. Lead programmer has minimum 5 years of experience on similar projects			
c. Firm has in-state registered electrical or control system engineer			
10. Firm is not in bankruptcy			
11. Firm is financially capable of completing the Project			
12. Firm has minimum of 20 full-time employees in I&C/programming work			
13. Firm has permanent local office within 200 miles of Project site.			
REFERENCE No. 1 Name			
1. Project PCS system cost of at least 1/2 of this Project estimated cost			
2. Number of new physical I/O points at least 75 percent of this Project			
3. Same PLC hardware or PCS software as this Project			
4. Water or wastewater facility			
5. At least 2/3 the number of PLCs as this Project, or greater			
6. At least 2/3 the number of operator stations as this Project, or greater			
7. Project substantially complete			

INSTRUMENTATION AND CONTROL SYSTEM CONTRACTOR EVALUATION CRITERIA	Contractor:	Contractor:	Contractor:
REFERENCE No. 2 Name			
1. Project PCS system cost of at least 1/2 of this Project estimated cost			
2. Number of new physical I/O points at least 75 percent of this Project			
3. Same PLC hardware or PCS software as this Project			
4. Water or wastewater facility			
5. At least 2/3 the number of PLCs as this Project, or greater			
6. At least 2/3 the number of operator stations as this Project, or greater			
7. Project substantially complete			
REFERENCE No. 3 Name			
1. Project PCS system cost of at least 1/2 of this Project estimated cost			
2. Number of new physical I/O points at least 75 percent of this Project			
3. Same PLC hardware or PCS software as this Project			
4. Water or wastewater facility			
5. At least 2/3 the number of PLCs as this Project, or greater			
6. At least 2/3 the number of operator stations as this Project, or greater			
7. Project substantially complete			

SECTION 17100
CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Contractor-developed loop description submittal requirements.
 - 2. General programming requirements.
 - 3. Common control functions:
 - a. General control and monitoring functions to be provided throughout the PCS system.
 - 1) These requirements apply to all systems, and supplement information indicated on the Drawings.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Hardwired control: Control circuitry that does not utilize software to initiate functionality.
- C. Hardwired interlocks: A safety or protective feature that will interrupt operation of the equipment in all operating modes with no required operator intervention.
- D. Software interlocks: A safety or protective feature that will interrupt operation of the equipment when the PLC has control.
- E. Slew rate: Rate of change in respect to time.
- F. Clamp: Imposed upper and lower limits on setpoints to eliminate entries outside the allowable control parameters.
- G. Watchdog timer: Timers imposed to test components such as discrete I/O to verify the health of the card.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Implementation as specified in Section 17765 - Control Systems: Programming Requirements.
- C. General programming requirements:
 - 1. Use variable names or aliases derived from tag and loop identification on the P&IDs for all process values.
 - a. Submit names for Owner approval.
 - b. Unless otherwise noted, utilize floating-point format for all PLC algorithms and calculations.
 - c. Provide PLC logic to convert raw input values into engineering units in a floating-point format.
 - 2. Store all adjustable parameters in the PLC, and configure so that an operator with sufficient security access can change the parameters from the LOI or HMI. Update and display the current value at all locations, regardless of where the last change was made.
 - 3. Reusable PLC code blocks:
 - a. Owner will provide standard user defined function blocks (UDFBs) and user-defined types (UDTs) for PLC programming. Utilize these standards wherever possible in PLC programming.
 - b. Develop and use new standard user defined function blocks (UDFBs) and user defined types (UDTs) where appropriate. One instance of each standard code block shall reside in each PLC and shall be referenced in main routines and subroutines.
 - c. New code blocks that the Contractor would like to use as a standard shall be submitted to Owner for review and approval.
 - d. Provide complete library of standard code blocks to Owner as part of O&M documentation.
 - 4. Documentation:
 - a. All control logic shall be completely annotated including all rungs, instructions, and tags.
 - b. Each routine shall have a title and a detailed description of the control strategy represented by the control logic. Where parameters are passed to the routine, all parameters shall be defined in the routine description.
 - c. Analog tag descriptions representing process variables shall include the engineering unit range of the analog variable.
 - d. Digital tag descriptions shall include the On and Off state labels.
 - e. Complete, grammatically correct sentences and terminology, consistent with water treatment processes, shall be utilized in the development of rung and routine descriptions.
 - f. All equations developed in the process logic shall be fully documented in the rung or routine description. A description of each constant and variable utilized in the equation shall be defined including engineering units.
 - 5. Program slew rates for setpoints as needed to limit the effect of updated setpoints on the process:

- a. Provide for control setpoints and manual speed and position selections.
 - b. Store new setpoints in one register, and gradually ramp the actual setpoint register at the slew rate until it reaches the new value.
 - c. Provide operator access to change slew rates from the HMI.
6. Saved setpoints:
 - a. Provide an operator selection to save all setpoint values.
 - b. Where possible use a DFB or AOI to provide an operator selection to restore all setpoints to the initial start-up value.
 - c. Provide an operator selection to restore all setpoints to the last saved value.
7. Store a copy of all adjustable parameters and accumulated and integrated totals in PCS:
 - a. Upon re-loading of the PLC program, re-load these values to the PLC from PCS or processor memory card.
 - b. PLCs provide a minimum 2 week data storage to provide for data accumulation and later communication to the Historian in the event of a network interruption.
8. Calculated values:
 - a. Program calculations such that division by zero errors cannot occur.
 - b. Prevent calculations from generating values that exceed the limits of the equipment or data type structures (integers) internal to the PLC.
 - c. Configure counting functions (start counts and operation counts) to allow a minimum of 10,000 counts, and to roll-over to zero at an even decimal interval (1 followed by 4 or more zeros).
 - d. Configure integrating functions to accurately accumulate the maximum rate from the instrument/equipment (totalizers, run time meters) for 30 years. Utilize manufacturer AOI/DFBs etc. where possible.
9. Timers:
 - a. Provide programmable settling and proving timers in control sequences as required for starting and stopping of equipment to allow the process to settle down before proceeding with any additional control functions.
 - 1) The settling timers may be overridden by setting the timer to 0 seconds.
10. Control Panel status:
 - a. Design the PLC system to function as a stand-alone unit that performs all of the control functions described in this Section completely independent from the functions of the PCS system PC-based operator interfaces:
 - 1) Failure of the PCS system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
 - b. Furnish a minimum of 1 screen that depicts the status of all enclosures containing PLCs, communication equipment, UPS or I/O in the control system, including but not limited to the following:
 - 1) PLC cabinet over-temperatures from high temperature switch.
 - 2) Intrusion status on all enclosures equipped with intrusion switches.
 - 3) AC power failure:
 - a) Monitor ahead of UPS.
 - 4) DC power supply failure:
 - a) For redundant power supplies, alarm when either power supply or the diode bridge fails.
 - 5) UPS failure signal.
 - 6) UPS Low Battery signal.
 - 7) Digital bus network Coupler and or Gateway failure signal.

- 8) Ethernet Switch failure signal.
11. PLC system communication status:
 - a. Furnish a minimum of 1 screen to display all communication errors and status within the PCS:

Communication between PCS and PLCs, PLC to PLC, PLC to RIO

 - 1) Modbus Gateway modules.
 - 2) Display status of each node, and summary of failures over the past 60 minutes.
 - b. Generate a communications alarm if any communication fault is detected or there is no response from a node for more than a user specified time.
 - c. In the event of communications loss:
 - 1) Continue normal operation at each PLC.
 - 2) Where control parameters are received over a communications link:
 - a) If a link fails where process elements use the remote value for closed-loop control, hold operating status, speed and position, of the process elements at their last state before the communication alarm, unless other I/O local to that PLC indicates shutdown or over-ride conditions:
 - (1) Ensure that the operator can control the process using PC/IS HAND mode at the local LOI.
 - b) If a link fails where process elements use the remote value to determine setpoints, continue to operate using the last value received:
 - (1) Provide a manual over-ride entry at the local LOI to allow an operator to enter a different value for any such remote signal.
 - (2) Generate an alarm whenever an over-ride value is in use.

D. Common control functions:

1. Incorporate common control functions into all control loops and devices and into the control programming, whether or not specifically shown in the specific control descriptions or elsewhere in the Contract Documents.
2. Alarms:
 - a. Generate alarms within the PLC logic.
 - b. Indicate alarms at the LOI and HMI. Enable acknowledgement from either the HMI or the LOI.
 - c. Generate high, high-high, low, and low-low level alarms where indicated:
 - 1) Provide an alarm reset deadband for each analog value to prevent excessive repeated alarms.
 - 2) Provide logic and timers to inhibit analog alarms based on process events. For example, inhibit low flow alarms when a pump is stopped, or has not been running long enough to establish flow.
 - d. Flash all alarm and fail conditions and their respective indicators on the PCS graphic screens and local indicating lights until the condition is acknowledged by the operator, even if the alarm condition is no longer present.
 - e. Once the alarm is acknowledged by an operator, display alarm conditions in a steady state (not flashing) while the alarm condition is still present:
 - 1) Flash with a cycle rate of 1/2 second on and 1/2 second off.
 - f. Once the alarm has been cleared and the operator has acknowledged the alarm or fail condition, turn the graphic alarm indicator off.

- g. For all alarms that do not have inherent timers, provide an operator-adjustable proving timer to limit nuisance alarms, continuously adjustable from zero seconds to 100 minutes. The initial setting of proving timers shall be zero seconds:
 - 1) The PLC shall start the timer when it first detects an alarm condition, and shall only activate the alarm after the timer has expired.
 - 2) If the alarm condition clears while the timer is running, the timer shall reset, and the alarm shall not be activated.
 - h. Use interlocks and proving timers to prevent alarms from operating due to power loss, except for loss of power alarms.
 - i. Furnish an alarm silence pushbutton at each PCM, LOI, or LCP with an audible alarm to signal the PLC to turn off the audible alarm until the next alarm occurs.
 - j. Call Out alarms that are not acknowledged after a setpoint period of time shall activate the auto dialer.
 - k. Lamp test: Furnish lamp test pushbuttons at each control panel with more than 10 pilot lights, that illuminates all pilot lights on the panel:
 - 1) The lamp test may sequence through blocks of lights.
 - 2) Minimum on time for each lamp during lamp test 15 seconds.
 - l. Horns and Beacons:
 - 1) Activate PCM horn and beacon on all critical alarms and on other alarms as defined by the Facility Alarm Philosophy.
 - 2) Deactivate PCM horn and beacon when PCM reset pushbutton is activated.
 - 3) Silence PCM horn when PCM silence pushbutton is activated.
 - m. Dual analog instruments:
 - 1) For applications where 2 or more analog instruments are measuring the same process variable:
 - a) Generate an operator adjustable percent deviation alarm.
 - b) Allow operator to take each instrument out of service when an instrument is out of service.
3. Where a reset is shown for counts, totals and times maintained in the PLC:
 - a. Provide a reset selection on the HMI screen that displays the value.
 - b. Provide a preset function on the HMI to allow an operator-entered value to become the current accumulated total.
 - c. Limit access to the reset and preset functions to operators with suitable security level.
 - d. Log the value before reset, operator, time, and date of reset in the PCS archive.
 - e. Log the value before preset, preset value, operator, time, and date of preset in the PCS archive.
 4. Where start counts are indicated on the Drawings, or required in this Section, count starts for each piece of equipment (off to on transitions of running status) in the PLC:
 - a. Display total starts on PCS screens, and provide a reset function.
 - b. Where indicated, calculate number of starts for each day:
 - 1) Display current day and previous day starts on PCS displays.
 - 2) Do not reset daily start count when overall count is reset.
 - 3) Archive starts for each day through PCS.
 5. Where run time accumulation is indicated on the Drawings, or required in this Section, integrate accumulated run time to the nearest 0.1 hour whenever the running status input indicates that the equipment is running:

- a. Display total run time in hours on PCS screens.
- b. Where indicated, calculate total run time for each day:
 - 1) Display current day and previous day run time on the HMI to the nearest 0.1 hour.
 - 2) Do not reset daily run time when overall time is reset.
 - 3) Archive run time for each day through PCS.
- 6. For all monitored analog values:
 - a. Convert all values to engineering units in floating-point format within the PLC.
 - b. Maintain trends in PCS.
 - 1) Display minima and maxima on the HMI, and archive through PCS.
 - c. Flows and Weights:
 - 1) Totalize flows in the PLC logic:
 - 2) Where totalized flows are input to a discrete input, count input pulses and multiply by the volume per pulse.
 - 3) Where no totalizer input is shown, integrate the analog input over time.
 - 4) Display totals on the HMI and LOI.
 - 5) Archive totals to the historical database through PCS.
 - d. Generate an alarm whenever an over-ride value is in use.
 - e. Calculate hourly, daily, and monthly averages:
 - 1) Calculations shall be performed by the PLC.
 - 2) Display averages on the HMI, and archive through PCS.
 - 3) Display minima and maxima on the HMI, and archive through PCS.
 - f. Calculate minimum and maximum values each day, and month:
 - 1) Calculations may be performed by the PLC or PCS.
 - 2) Display minima and maxima on the HMI, and archive through PCS.
 - g. Generate an alarm whenever an over-ride value is in use.
- 7. Analog data processing:
 - a. Engineering units conversion:
 - 1) Use engineering units for all analog point values. Convert analog inputs to engineering units.
 - b. Analog magnitude checking:
 - 1) Provide upper and lower limits to prevent operator-entered values (setpoints, etc.) from falling outside acceptable limits.
 - c. Analog value quality:
 - 1) Monitor analog values received at each PLC from analog inputs or communications from another PLC or RIO specific to critical analog values, and generate alarms for the following conditions:
 - a) Rate of change in excess of acceptable limit:
 - (1) Provide a separate rate limit for each value.
 - b) Stale value:
 - (1) For analog signals that come from analog inputs or calculations using analog inputs, which are expected to have some variation each time the input is read, alarm when there is no change in the value for 10 times the normal expected scan or communication update.
- 8. Analog device override (LOI and HMI):
 - a. Provide the following functions from the HMI and the local LOI all controlling analog input:
 - 1) An over-ride value to be used in place of the analog input:
 - a) Enter in engineering units:

- (1) Display the calibrated range in engineering units.
 - (2) Only allow entries within the calibrated range of the instrument.
 - b) When the analog input is enabled, track the analog input so that the over-ride matches the analog input value when the input is initially disabled.
 - c) Maintain over-ride status and value in the PLC.
 - d) Only allow access to over-ride selections and settings to operators with sufficient security.
 - 2) An enable/disable selection:
 - a) When enabled, the value used by the PCS system is equal to the analog input value.
 - b) When disabled, the analog input is ignored, and the over-ride value is used for all control and display functions.
 - c) Generate an alarm whenever an analog input is disabled.
 - d) Enter a value for the analog input from the PCS system to the PLC.
 - 3) Use the over-ride value for all display and control functions instead of the actual analog input value.
- b. Provide the following functions in the PLC, with selections and value entry from the HMI and/or LOI:
- 1) An over-ride value to be used in place of the normal output value:
 - a) Enter in percent of output span.
 - b) When the analog output is enabled, track the analog input so that the over-ride matches the analog output value when the output is initially disabled.
 - 2) An enable/disable selection:
 - a) When enabled, the value sent to the output is the value determined by the PLC based on the control logic or operator-entered value in PCS HAND.
 - b) When disabled, the calculated PCS HAND values are ignored, and the over-ride value is sent to the output.
 - c) Generate an alarm whenever an analog output is disabled.
9. Tank and vessel levels:
- a. Display all tank and vessel levels as both a level (typically in feet) and a volume (typically in gallons):
 - 1) Some individual displays may be only level or volume, when agreed to by the Owner and Engineer during screen meetings.
 - b. Monitor rate of change of volume on all tanks and vessels:
 - 1) Establish the maximum withdraw rate at which the volume should decrease (all pumps or feeders operating at maximum output). Generate an alarm whenever the volume decreases faster than this rate.
 - 2) Establish the minimum fill rate at which the volume should increase when filling. Generate an alarm whenever the volume increases faster than this rate. Verify tank and vessel level is fluctuating to verify the validity of the IO register. If it is determined the register is not active or failed in a manner that leaves a stagnant value generate an alarm.
10. I/O filtering and processing:
- a. Analog input filtering:

- 1) For each analog input provide an adjustable first order filter, for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, configure analog inputs with no filtering affect.
 - 2) Monitor analog input signal quality:
 - a) Over range: The input value is above the normal range (typically over 21 mA).
 - b) Under range: The input value is below the normal range (typically under 3 mA, indicating a probable broken connection).
 - c) Generate alarms for over or under range inputs.
 - d) Do not use over or under range values for control or calculation purposes:
 - (1) Where a second instrument is provided to monitor the same condition (a redundant instrument, or additional instruments furnished for averaging or different operating modes), and has a valid signal, use that input for control.
 - (2) Otherwise, hold all outputs affected by the signal at their last values before the signal went out of range.
 - 3) Digital input filtering (proving timer):
 - a) Provide an adjustable time delay function (0-10 seconds) on discrete input for the purpose of de-bouncing.
 - b) By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.
11. Instrument scaling (HMI/LOI):
- a. Provide 1 or more maintenance screens to display ranges and trigger points for all field instruments:
 - 1) For analog instruments, use input scaling values in the PLC to determine minimum and maximum calibration points.
 - 2) For discrete instruments, display calibrated pick-up and drop-out values.
12. PCS HAND-OFF-AUTO:
- a. Where indicated, provide HAND-OFF-AUTO and START-STOP selections in the PCS, accessed from an LOI or HMI for operators with sufficient security, to provide the following operating modes:
 - 1) PCS AUTO: The normal, automatic control mode of the strategy which allows full PLC control in response to process conditions and programmed sequences.
 - 2) PCS HAND: Enables PCS Manual control where control decisions are made by an operator through the PCS START-STOP, OPEN/CLOSE, or other selections as indicated.
 - 3) PCS OFF: Automated PCS control is disabled and PLC calls for all associated equipment to stop and valves to close or go to their identified safe state.
 - 4) Program the PLC so that switching a strategy between AUTO and HAND (either direction) occurs with a smooth transition. Keep running or position status unchanged when control is switched to HAND until a change is requested using the operator selections (START, STOP, OPEN, CLOSE). Keep running and position status unchanged when control is switched to AUTO until the control logic determines a change is required.
13. Display the current status of all operator selections (PCS HAND/AUTO, PCS START/STOP, etc.) on LOI and HMI.

14. Interlocks:
 - a. Implement software interlocks where indicated to place equipment in a safe condition in response to impending hazardous process conditions. Apply software interlocks when equipment is operating in PCS AUTO or PCS HAND:
15. Permissives:
 - a. Implement software permissives where indicated to prevent equipment from starting in an unsafe condition.
 - b. Apply software permissives when equipment is operating in PCS AUTO or PCS HAND.
16. Process control algorithms:
 - a. Jog and hold: Unless otherwise indicated, use jog and hold control algorithms where possible:
 - 1) When the error between process variable and setpoint is beyond a setpoint deadband:
 - a) Jog valve or ramp speed in the required direction for a preset "Jog Time" or until the process variable reaches or passes the setpoint.
 - b) Then hold speed or position through a setpoint "Hold Time."
 - c) Continue alternating jog and hold until the error is less than the deadband.
 - 2) Provide operator access to Jog Time and Hold Time setpoints from the HMI.
 - b. PID algorithms: Use where indicated, or where necessary to provide fast response:
 - 1) Provide a PID faceplate with the following displays and functions for each PID control algorithm:
 - a) Display Output, CV.
 - b) Display Setpoint, SP.
 - c) Display Process Variable, PV.
 - d) Allow for operator selection of Automatic or Manual control of the output.
 - e) Under Manual control of output allow the operator to enter the desired output value.
 - f) Allow for input of the 3 Proportional, Integral, and Derivative tuning parameters.
 - g) Configure PID loops to prevent reset windup when controlled equipment is operating in Manual (local or PCS), or when the equipment has reached a physical limit.
 - h) When controlled equipment is being operated in remote PCS HAND, configure the PID function to track the process variable to provide a smooth transfer between Manual and Automatic modes.
17. Equipment alternating and sequencing:
 - a. Distribute number of starts and run time equally between identical equipment.
18. Motor control:
 - a. Monitor the device's LOCAL-OFF-REMOTE (LOR) switch (the hard-wired switch at the MCC, drive or equipment) to determine when the PLC has control of the associated equipment:
 - 1) Display current REMOTE status on the PCS screens.

- b. Monitor the device's running status from the starter auxiliary or run status input:
 - 1) Display the current status (running or stopped) on the PCS screens.
 - 2) Use status to calculate total run time and daily run time, and to count total starts and daily starts.
 - 3) Provide time stamp for each start.
 - 4) For motors 200 HP and greater, provide software to prevent exceeding the manufacturer's recommended maximum starts per hour.
- c. When equipment control has been given to the PLC as reported by the LOCAL-OFF-REMOTE switch, allow selection of PCS AUTO or PCS HAND control modes based upon operator selection using the PCS screens.
- d. Starting, stopping and running when the device LOR is in LOCAL:
 - 1) With the LOR switch in the LOCAL position, the motor is controlled by the START and STOP pushbuttons.
 - 2) With the LOR switch in the OFF position, the motor is prohibited from running.
 - 3) With the LOR switch in the REMOTE position, the motor is controlled remotely.
- e. Starting, stopping and running when the device LOR is in REMOTE:
 - 1) When the motor is expected to be running (PLC has issued a START or RUN due to process conditions or operator selection), LOR is in REMOTE, and the device is not reported to be running, start an operator adjustable "Control Activation" timer:
 - a) Provide "Control Activation" timers for each piece of controlled equipment:
 - (1) If the LOR and required running status do not change, and the PLC does not receive running status within the "Control Activation" time period:
 - (a) De-activate the output.
 - (b) Place the device in a "Failed" state.
 - (c) Generate a "Failed to Respond" alarm.
 - 2) When the motor is not expected to be running (PLC has issued a STOP or removed the RUN output), LOR is in REMOTE, and the device is reported to be running, start the "Control Activation" timer:
 - a) If the LOR and required stopped status do not change, and the PLC does not lose the running status within the "Control Activation" time period:
 - (1) Keep the RUN output off or the STOP output on.
 - (2) Place the device in a "Failed" state.
 - (3) Generate a "Failed to Respond" alarm.
 - 3) Re-establish PLC control of a device in a "Failed" state only after the following:
 - a) An operator turns the device's LOR switch out of REMOTE, and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
- f. Where motor winding high temperature switches or RTD temperature elements are shown, generate an alarm when high temperature is sensed (contact opens or temperature above the high alarm setpoint), but do not stop the motor unless otherwise indicated.

- g. Motor equipped with current detection shall shut down and report a “failed” status on detection of high current.
- h. Control two-speed motors similar to other motors, except as listed below:
 - 1) Motor states are RUN-FAST, RUN-SLOW, and STOP.
 - 2) Start all two-speed motors in the RUN-SLOW state. If or when the high speed is required (RUN-FAST operator selection or process conditions), transition to RUN-FAST after a designated time.
 - 3) When transitioning from RUN-FAST to RUN-SLOW, remove the RUN-FAST output or issue a STOP, then wait for a “Fast to Slow” time delay before energizing the RUN-SLOW or START-SLOW output.
- i. Simultaneous starts:
 - 1) Prevent more than one motor-driven load 25 HP or larger in the same facility from starting concurrently:
 - a) When starting one load, inhibit start logic for all other such equipment until the load being started is up to speed (RVSS or VFD), or after a setpoint time delay (full-voltage starters and miscellaneous equipment).
- j. Speed control:
 - 1) Modulate speed on VFD-driven motors using jog and hold, or PID control algorithms to maintain process conditions as described in the specific loop descriptions.
 - 2) Operate speed control within a pre-defined range:
 - a) Minimum speed as determined by equipment manufacturer. The higher of:
 - (1) Minimum motor speed to maintain adequate cooling for the type of load driven (constant or variable torque).
 - (2) Minimum equipment speed, such as minimum speed to deliver flow or to deliver minimum flow for equipment cooling or lubrication.
 - b) Maximum speed 100 percent (60 hertz) or as identified by equipment manufacturer.
 - 3) Where multiple equipment may operate together to maintain the same process condition:
 - a) Provide an operator selection for starting sequence.
 - b) Start the first equipment at a preset starting speed.
 - c) When one or more equipment is running and the speed control algorithm reaches a preset “Start Next” speed value (initially 95 percent of speed range) through a preset time delay:
 - (1) Start the next available equipment at the preset starting speed.
 - (2) Ramp up the started equipment and ramp down the previously running equipment to the mid operating speed (adjustable in the PLC). Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with the new load running at the mid speed (for example if one pump is running and the second pump will be added, then the total flow of both pumps running at mid operating speed should be approximately the same as flow of one pump at Start Next speed).

- (3) Once both equipment reach the mid operating speed, resume the speed control algorithm for those equipment.
 - (4) Operate all equipment at the same speed following the output of the speed control algorithm.
 - d) When two or more pieces of equipment are running, monitor for a “Stop Next” condition:
 - (1) Where flow rate is monitored, use a preset “Stop Next” flow rate for each possible number and combination of equipment:
 - (a) Determine initial “Stop Next” speed based on the flow that can be provided with one fewer piece of equipment running at a speed slightly below the “Start Next” speed.
 - (2) When the “Stop Next” condition exists through a preset time delay:
 - (a) Ramp speed of running equipment except for the equipment to be stopped up to a preset value based on the number of items running. Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with one fewer load running (typically slightly below the preset “Start Next” speed) while ramping speed of equipment to be stopped down to the preset minimum speed.
 - (b) Operate all remaining equipment at the same speed following the output of the speed control algorithm. Stop the load once it reaches minimum speed.
- 19. Gate and valve control:
 - a. Monitor the device’s LOCAL-STOP-REMOTE (LSR) switch(es) (the integral switch in the actuator or hard-wired switch at the local control station):
 - 1) Display current REMOTE status on PCS screens.
 - b. Start an “Open Activation” timer whenever the device is expected to be open (PLC has issued an OPEN command in PCS AUTO, or OPEN was selected in PCS HAND):
 - 1) Initially set “Open Activation” time to twice the normal opening time.
 - 2) If the LSR position and open command do not change, and the PLC does not receive fully open status feedback within the “Open Activation” time period:
 - a) De-activate the open output.
 - b) Place the device in a “Failed” state.
 - c) Generate a “Failed to Open” alarm.
 - c. Start a “Close Activation” timer whenever the device is expected to be closed (PLC has issued a CLOSE command in PCS AUTO, or CLOSE was selected in PCS HAND):
 - 1) Initially set “Close Activation” time to twice the normal closing time.
 - 2) If the LSR position and close command do not change, and the PLC does not receive fully closed status feedback within the “Close Activation” time period:
 - a) De-activate the close output.
 - b) Place the device in a “Failed” state.
 - c) Generate a “Failed to Close” alarm.

- d. Limit the number of open/close /commands so that it does not exceed the manufacturer requirements.
 - e. For modulating valves (valves controlled from either a 4-20 mA signal or digital communications command) with position feedback, start a "Position Error" timer whenever the position feedback differs from the required position command by more than a setpoint error when the LSR is in REMOTE:
 - 1) For analog modulating devices, error is determined by position feedback differing from position command by more than the setpoint error.
 - 2) For discrete modulating devices, error is determined by feedback not changing in the correct direction, or changing at less than a setpoint rate, when the OPEN or CLOSE PLC output is active.
 - 3) Initially set the "Position Error" time to 60 seconds.
 - 4) If the LSR position does not change, and position error stays outside of the setpoint error through the "Position Error" time period:
 - a) Place the device in a "Failed" state.
 - b) Generate a "Position Fail" alarm.
 - f. Provide separate time delay settings for each function and for each device.
 - g. If the valve position inputs indicate an invalid state (i.e., valve open and closed at the same time), place the device in a "Failed" state and generate an "Invalid State" alarm.
 - h. Re-establish PLC control of a device in a "Failed" state only after one of the following:
 - 1) An operator turns the device's LSR switch out of REMOTE and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
 - 2) An operator acknowledges the fault from PCS.
 - i. For all alarm conditions, control other devices (as stopping pumps, etc.) as stated in the individual loop descriptions to make the system safe.
 - j. For discrete modulating valves (valves positioned to intermediate positions to control process values through discrete OPEN and CLOSE outputs), count the number of actuations (OPEN or CLOSE commands) per hour in the PLC:
 - 1) Display count on the HMI.
20. Chemical systems (LOI/HMI):
- a. Provide the following chemical system screens:
 - 1) Where one LOI manages more than one chemical system, a main menu screen that will allow the operator to access the individual chemical system screens using software keys.
 - 2) One or more screens for each individual chemical system controlled at that location, containing:
 - a) All status displays (running, failed, etc.).
 - b) Selections (lead/lag, which process flow to pace to, etc.).
 - c) Setpoint entry and display.
 - d) Calculated feed requirement (result of flow pacing calculation) in engineering units (typically milligrams of chemical per minute).
 - e) Output signal to feeder in percent of full span.
 - f) Actual chemical flow rate from flowmeter (where shown).
 - g) Process flow rate(s) used to pace each chemical on the individual chemical screens (PROC FLOW):

- (1) Where different process flows can be selected for flow pacing, display and identify the selected source.
- b. Chemical system calculations: Perform calculations as indicated on the Drawings and in the individual loop descriptions. Use the following assumptions, unless otherwise noted:
 - 1) Where chemical flow feedback is not used, assume feeder output is linear in response to control signal.
 - 2) Zero signal (typically 4 milliamperes) produces zero flow.
 - 3) Perform flow-pacing calculations using as indicated on the Drawings or described in the individual loop descriptions.
- c. Provide the setpoints and selections indicated on the Drawings and in the individual loop descriptions. Typical setpoints include:
 - 1) QMAX: Maximum calibration value:
 - a) Chemical flow rate measured from calibration column at maximum feeder output (typically in gallons of solution per hour or milliliters of solution per minute).
 - 2) CONC: Chemical concentration:
 - a) The concentration of the chemical in the solution to be fed, in engineering units (typically milligrams of chemical per liter of chemical solution).
 - 3) DENSITY:
 - a) Density of the chemical solution to be fed in engineering units or as a specific gravity.
 - b) Used to calculate the concentration of the chemical in the solution.
 - 4) DOSE: Desired dosage:
 - a) Desired chemical concentration in the process stream in engineering units (typically milligrams of chemical per liter of process fluid).
 - 5) FLOW SEL: Selection of process stream(s) for flow pacing.
 - 6) OPEN/CLOSED LOOP:
 - a) Selection of method of controlling chemical flow-paced feed rate.
 - b) OPEN LOOP: Signal to feeder is based on feeder calibration (QMAX) to deliver calculated chemical solution feed rate. Chemical solution flowmeter is not used for control.
 - c) CLOSED LOOP: Chemical feed rate is directly controlled using the calculated chemical solution feed rate as the setpoint, and the flow rate from the chemical solution flowmeter as the process variable.
 - 7) TRIM FACTOR: Adjusts the desired impact of the trim multiplier. Adjustable from 0 to 1.
 - 8) QAH: Desired setpoint for top of band for analyzer trim control.
 - a) QAL: Desired setpoint for bottom of band for analyzer trim control.
- d. Chemical control algorithms:
 - 1) Flow pacing algorithm: Operator selects a desired dose and the control system adjusts the chemical feed rate to dose based on process flow, chemical concentration, and feeder calibration. The calculation is as follows (units may vary from those shown in the calculation below):

$$FEEDER\ FLOW\ (gph) = \frac{34,897 * DOSE\left(\frac{mg}{L}\right) * PROCESS\ FLOW(MGD)}{CONC(\%) * DENSITY\left(\frac{lb}{gal}\right)}$$

$$FEEDER\ FLOW\ (\%) = \frac{FEEDER\ FLOW(gph)}{QMAX(gph)}$$

- 2) Flow pacing with closed loop algorithm: Operator selects a desired dose and the control system adjusts the speed of the chemical feeder through a speed control signal to match the measured chemical feed rate to a flow rate setpoint. This flow rate setpoint shall be derived from the process flow and operator setpoints for dosage and concentration. The calculation is as follows (units may vary from those shown in the calculation below):
-

$$FEEDER\ FLOW\ (gph) = \frac{34,897 * DOSE\left(\frac{mg}{L}\right) * PROCESS\ FLOW(MGD)}{CONC(\%) * DENSITY\left(\frac{lb}{gal}\right)}$$

- a) Adjust the speed of the chemical feeder using a PID control algorithm to maintain the calculated FEEDER FLOW:
- (1) SP = Calculated FEEDER FLOW.
 - (2) PV = Chemical Flow.
 - (3) CV = Speed of the Chemical Feeder.
- 3) Flow pacing with analyzer trim algorithm: Operator selects a desired dose and desired analyzer setpoint band and the control system adjusts the chemical feed rate to dose based on process flow, chemical concentration, process analyzer output, and feeder calibration. The calculation is as follows (units may vary from those shown in the calculation below):

$$PRE\ TRIM\ FLOW\ (gph) = \frac{34,897 * DOSE\left(\frac{mg}{L}\right) * PROCESS\ FLOW(MGD)}{CONC(\%) * DENSITY\left(\frac{lb}{gal}\right)}$$

$$TRIM\ MULTIPLIER = \frac{AI - \frac{1}{2}(QAH + QAL)}{-\frac{1}{2}(QAH - QAL)}$$

CLAMP THE TRIM MULTIPLIER OUTPUT TO A MAXIMUM OF 1 AND MINIMUM OF -1.

$$TRIM\ ADDER(gph) = TRIM\ FACTOR * TRIM\ MULTIPLIER * PRE\ TRIM\ FLOW(gph)$$

$$FEEDER\ FLOW(gph) = PRE\ TRIM\ FLOW(gph) + TRIM\ ADDER(gph)$$

$$FEEDER\ FLOW\ (\%) = \frac{FEEDER\ FLOW(gph)}{QMAX(gph)}$$

- 4) Flow pacing with closed loop and analyzer trim algorithm: Operator selects a desired dose and desired analyzer setpoint band and the control system adjusts the speed of the chemical feeder through a speed control signal to match the measured chemical feed rate to a flow rate setpoint. An additional control algorithm is used in the calculation to fine-tune the feed based on an analytical measurement as measured by the process analyzer.

$$PRE\ TRIM\ FLOW\ (gph) = \frac{34,897 * DOSE\left(\frac{mg}{L}\right) * PROCESS\ FLOW(MGD)}{CONC(\%) * DENSITY\left(\frac{lb}{gal}\right)}$$

$$TRIM\ MULTIPLIER = \frac{AI - \frac{1}{2}(QAH + QAL)}{-\frac{1}{2}(QAH - QAL)}$$

CLAMP THE TRIM MULTIPLIER OUTPUT TO A MAXIMUM OF 1 AND MINIMUM OF -1.

$$TRIM\ ADDER(gph) = TRIM\ FACTOR * TRIM\ MULTIPLIER * PRE\ TRIM\ FLOW(gph)$$

$$FEEDER\ FLOW(gph) = PRE\ TRIM\ FLOW(gph) + TRIM\ ADDER(gph)$$

- a) Adjust the speed of the chemical feeder using a PID control algorithm to maintain the calculated FEEDER FLOW:
 - (1) SP = Calculated FEEDER FLOW.
 - (2) PV = Chemical Flow.
 - (3) CV = Speed of the Chemical Feeder.
- e. Virtual day tanks:
 - 1) Chemical systems without actual day tanks will have their own “virtual” day tank, which will use either a pre-set volume (operator adjustable) or a calculated daily use rate based on the totalized flow (volume) of the chemical magnetic flowmeters over the virtual day tank cycle. The “virtual” day tank will start at the pre-set volume or the calculated volume (operator-selectable) and based on the storage tank level, the volume in the “virtual” day tank will decrease until the total “volume” in the virtual day tank is used. The virtual day tank will automatically compensate for any changes in the system due to the use of the dilution system (revised solution concentration). Once this occurs, the operator will be provided with a “pop-up” screen stating that the “virtual” day tank volume is used. Once this occurs, the operator will be provided with a “pop-up” screen stating that the virtual day tank needs to be refilled. The pop-up screen will contain the following information:
 - a) Time {hours and minutes} since the last day tank filling.
 - b) Volume utilized in the “virtual” day tank (based on the level transmitter measuring the chemical storage tank).
 - c) Dose {mg/L} based on the average flow rate over the “virtual” day tank cycle.
 - d) Target dose {mg/L} based on operator input.
 - 2) Provide a double check using the actual flowmeter values to compare with the calculated dose. Compared the magnetic flowmeter

- value with the calculated dose. The magnetic flowmeter value will be based on an hourly average of chemical flow rate over the day tank cycle.
- 3) As an added level of control any chemical system that has an analyzer used for feedback will be tracked and alarmed if outside the operating parameters.
 - 4) Alarm if any condition falls outside of the flow, or level parameters.
21. Breaker status:
- a. Display the following data to the extent it is available from the specified device:
 - 1) Open.
 - 2) Closed.
 - 3) Tripped.
 - 4) Ground fault.
 - 5) Settings.
 - 6) Racked out.
22. Power Data:
- a. Retrieve data from:
 - 1) Power Quality Meters (PQMs) at 480V.
 - 2) Main Breaker Protective Relays on Medium Voltage Switchgear.
 - 3) Generator Master Control Panel.
 - 4) Digital bus networks, as indicated.
 - 5) Where available, use Modbus TCP communications.
 - b. Display the following data (to the extent it is available) from the specified device.
 - 1) Current (A):
 - a) A-Phase.
 - b) B-Phase.
 - c) C-Phase.
 - 2) Volts (V):
 - a) A-Phase.
 - b) B-Phase.
 - c) C-Phase.
 - 3) Reactive power (kVAR).
 - 4) Real power (kW).
 - 5) Apparent power (kVA).
 - 6) Power factor.
 - 7) Energy (kW*hr).
 - 8) Demand peak (A).
 - 9) Demand peak (kW).
 - c. For engine/generator system monitoring, also display percent of rated output.
23. Power Supply and Distribution displays Power Quality Meters display:
- a. In addition to the Power Data listed above, display the following (where available) from PQMs, Protective Relays, and Generator Master Control Panel:
 - 1) Frequency(Hz).
 - 2) THD (current and voltage): up to 31st harmonic.
 - b. Calculate, indicate, historize, and trend data in a Medium Voltage Meter Table that lists measurements from the following Protection Relays:
 - 1) Protection Relay on 52-G1.
 - 2) Protection Relay on 52-G2.

- 3) Protection Relay on 52-M1.
- 4) Protection Relay on 52-M2.
- 5) Protection Relay on 52-M3.
- 6) Display calculated values for "Load At X.X kV", which sums the current, kW, and kW-hr values for all five Protection Relays.
- 7) Display calculated values for "Load At 480V", which sums the current, kW, and kW-hr values for all PQM meters.
- 8) Display calculated values for "Transformer and Line Losses", which subtracts "Load at 480V" from "Load At X.X kV" for current, kW, and kW-hr values for all PQM meters.
- c. Display the data in a 480V Meter Table that lists measurements from all power quality meters on the plant.
24. Digital bus Starters, RVSS and VFDs equipped with Ethernet communications:
 - a. Communicate and display all values listed in the equipment specifications, indicated on the Drawings, or listed below.
 - b. Communicate start and stop commands, and receive running feedback over the fieldbus network.
 - c. Provide data entry screen for the cost of electricity in dollars per (kw*hr), which will be used in calculations for display.
 - d. Monitor the following additional values, and display on the HMI:
 - 1) Motor current, phase A, B, and C.
 - 2) Over current alarm.
 - 3) Under current alarm.
 - 4) Running status.
 - 5) Phase loss.
 - 6) Stall.
 - 7) Number of starts.
 - 8) History of past 5 trips.
 - e. Calculate, indicate, historize, and trend, the following additional values:
 - 1) Full Load Amps (static value, Engineer will provide).
 - 2) Average Motor Operating Current.
 - 3) Run Time (Hours).
 - 4) Operating Hours (Hours/Year).
 - 5) Average Load Factor (equals Average Motor Current Operating Current/Full Load Amps) - *display as a percentage*.
 - 6) Annual Energy Use (kW*hr).
 - 7) Annual Operating Cost (dollars).
 - 8) Percent of Site Electric Use (equals Annual Energy Use/Sum of Annual Energy (kW*hr) values for all PQM meters).
 - f. For Variable Frequency Drives:
 - 1) Speed command.
 - 2) Speed feedback.
 - g. For RVSS, Variable Frequency Drives, and where otherwise shown or available, monitor the following over the digital bus network:
 - 1) Line voltage.
 - 2) Power.
 - 3) Power factor.
 - 4) Over voltage alarm.
 - 5) Under voltage alarm.
 - 6) Over current alarm.
 - 7) Under current alarm.

- 8) Indicate, historize, trend, and alarm data as indicated in the ACS I/O Tables on the Drawings.
25. Calculate, indicate, historize, and trend plant-wide calculated values for kW by the following Groups.
 - a. Calculated values (summed from starter data for all equipment within the Groups identified below):
 - 1) Demand peak (A).
 - 2) Demand peak (kW).
 - 3) Electric Power Consumption, by Process Group (kW).
 - 4) Electric Power Consumption, by Process Group (%): equals Electric Power Consumption, by Process Group (kW)/Sum of Electric Power Consumption on all 480V Meters.
 - 5) Electric Energy Consumption, by Process Group (kW*hr).
 - 6) Electric Energy Consumption, by Process Group (%): equals Electric Energy Consumption, by Process Group (kW)/Sum of Electric Energy Consumption on all 480V Meters.
 - b. Groups - Engineer to provide lists of starters (FVNR, RVSS, VFD, and monitored feeder breaker).
 - c. Display a Process Energy Consumption Table that lists the calculated values for each of the identified Groups.
 - d. Display a Process Energy Pie Graph that portions wedges according to the values calculated in Electric Energy Consumption, by Process Group (5). Label wedges, (with numeric percentage), for Groups to cover at least 90 percent of the Pie Graph. The remainder wedge of Pie Graph area can be labelled as "Other" (with numeric percentage).
26. Instruments equipped with digital bus communications:
 - a. Communicate and display all values listed in the equipment specifications, indicated on the Drawings, or listed below:
 - 1) Instrument diagnostics.
 - 2) Communications health.
 - 3) Process variable.
 - 4) Alarm summary.
 - 5) All totalizers (if applicable).
 - 6) Indicate, historize, trend, and alarm data as indicated in the ACS I/O Tables on the Drawings.
27. Calculate, indicate, historize, and trend calculated values for additional, process-specific measurements. Algorithms will be provided by the Engineer.
 - a. Influent:
 - 1) Influent flows (diurnally) vs. time (mgd vs. hours for 2 weeks, running).
 - 2) Influent flows (daily vs. time (mgd vs. *day of the week* for 1 week, running).
 - 3) Influent flows (diurnally) vs. time (mgd vs. *month of the year* for the last 3 years, running).
 - b. Aeration basins:
 - 1) BOD loading rate vs. time.
 - 2) MLSS in Aeration Basins vs. time.
 - 3) Solids retention time (total and aerobic) vs. time.
 - 4) Aerobic solids retention time and WW temperature vs. time.
 - 5) Aerobic solids retention time and WAS load vs. time.
 - 6) Aerobic solids retention time and MLSS vs. time.
 - 7) Sludge volume index vs. time.

- 8) Effluent ammonia and nitrate, phosphorus vs. time.
- c. Secondary clarifiers:
 - 1) Surface overflow rate vs. time.
 - 2) Solids loading rate vs. time.
 - 3) Effluent TSS vs. time.
 - 4) Solids blanket depth vs. time.
 - 5) RAS flows and percent of influent vs. time.
- d. Effluent.
- e. Solids treatment.
- f. Plant-wide process measurements:
 - 1) Surface overflow rate vs. time.
 - 2) Solids loading rate vs. time.
 - 3) Effluent TSS vs. time.
 - 4) Solids blanket depths vs. time.
 - 5) RAS flows and percent of influent vs. time.
- 28. Valves and gate operators equipped with digital bus communications:
 - a. Communicate and display all controls and data listed in the equipment specification, as indicated on the Drawings, or listed below:
 - 1) Open, close or direct position commands.
 - 2) Fully open and closed status.
 - 3) Position.
 - 4) High torque, overload and other applicable alarms.
 - 5) Indicate, historize, trend, and alarm data as indicated in the ACS I/O Tables on the Drawings.
 - b. Establish initial torque curves using manufacturer's software for performance tracking and wear.
- 29. Power failure:
 - a. Retain all operating setpoints during power failure.
 - b. Restore plant operation to the state it was before the power loss:
 - 1) Store the operating state of all major equipment and systems in the PLC, and retain the last state during a power loss.
 - c. Provide an operator selection to permit the plant to re-start. Once re-start is selected:
 - 1) Allow plant loads to re-start, and allow loads to sequence on and ramp up following normal control logic. Where loads were operating in PCS HAND, restore their operation to the state before the power loss.
 - 2) Use the logic described above for preventing concurrent starts to provide necessary delays between each start.
 - d. Operating on generator power:
 - 1) Include running and starting kW and kVA requirements for each major equipment and system in registers in the PLC:
 - a) Where running load can vary due to speed, valve position, etc., use the normal starting value plus 25 percent of the difference between the maximum and minimum values.
 - 2) Inhibit starting of loads from process control logic and from operator selection (in PCS HAND) that will exceed generator capability.
 - 3) Generate the following alarms:
 - a) Generator near capacity: When measured kW or kVA reaches 90 percent of the rating of running generators.
 - b) Generator at capacity: When measured kW or kVA reaches 95 percent of the rating of running generators.

- c) Unable to start: When an operator selects a load that would exceed generator starting or running capacity.
 - d) Insufficient capacity: When the control system needs to start a load, but is inhibited due to generator capacity.
- 4) Whenever the Generator at Capacity alarm is active, inhibit starting of any loads, and inhibit increase in speed of all control loops, and other changes that would increase electrical load.
- 5) Display the following power system data on the HMI and LOI in numerical and graphical formats:
 - a) Available power.
 - b) Current power demand.
 - c) Capacity of the generator.
 - d) Current power demand load as a percentage of capacity.
 - e) Generator frequency.

3.05 REPAIR/RESTORATION (NOT USED)

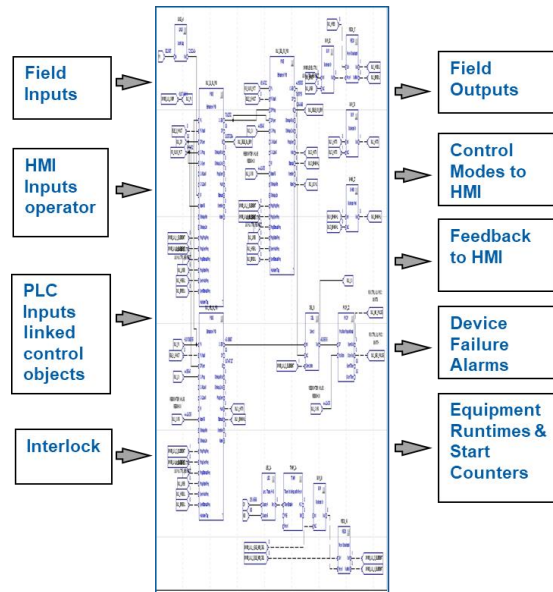
3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

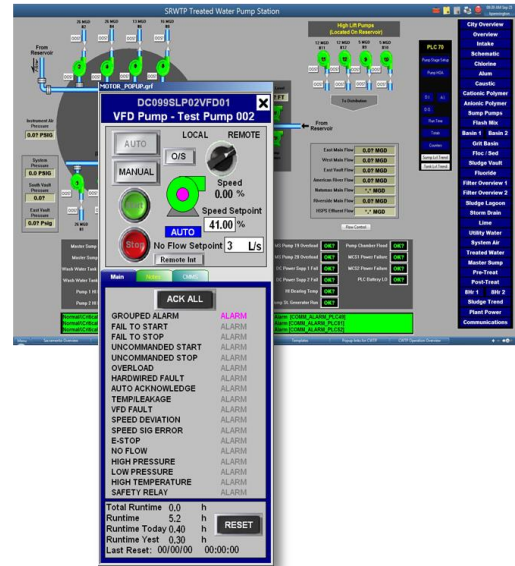
- A. Documentation
 - 1. Document all programming using both embedded comments within the program and creation of a programming manual.
- B. Program Comments
 - 1. Comments shall be used for all programming logic and functions. All functions and code not included in the programming manual shall include comments.
 - 2. Comments shall be used at the beginning of each function and sub-function to describe the overall operation of that function.
 - 3. Comments shall include date of comment and name of commenter.
 - 4. Comments shall be entered to track all revisions after substantial completion.
- C. Programming Manual
 - 1. The programming manual shall provide a description of the overall control system including types of controllers, types of SCADA HMI software, and including programming software versions and build numbers. The description shall also include processes included in the particular project.
 - 2. Include the following company and programmer information:
 - a. Company Name, Address, and contact phone number
 - b. Company Project Number
 - c. Project Manager Name
 - d. Lead Programmer Name
 - e. Manual Date
 - 3. Control Description
 - a. Project a general control description for the intended automated control programmed into the system. This should be written so that a non-programmer can understand the intended functionality of the system.
 - 4. Function Block Descriptions
 - a. Provide descriptions of all function blocks to document inputs and outputs and a general description of the block's use, e.g. Standard Variable

- Speed Motor function block to monitor and control pump speed and provide indication of critical variables and operational status.
 - b. Provide a representation of the function block for clear identification.
 - c. Provide a detailed description of the function block operation.
 - d. Provide a description of all input and output parameters including parameter name, data type, description, and any default values.
 - e. See example Function Block Diagram documentation example attached at the end of this section for requirements and format.
- 5. Graphical Screen Descriptions
 - a. Provide screenshots of all graphical screens developed for the project.
 - b. Group screen descriptions in the following categories:
 - 1) Overall Screen Standards:
 - a) Colors, Font, and Size for Standard Text: Static, Dynamic
 - b) Identification of Variable display versus a user Input
 - c) Standard Color conventions for functions such as On/Off/Fail
 - d) Descriptions of standard re-occurring graphical icons such as motors, pumps, pipe, valves, blowers, etc. Provide a description or graphical representations showing the possible state of each graphic.
 - 2) Navigation: General description of the navigation functions for each screen. Typical description covering the entire project.
 - 3) Alarm Management: General description of the on page and overall alarm management page. Include the following information:
 - a) Alarm Hierarchy: Critical, High, Warning, Low, Event
 - b) Associated alarm colors.
 - c) Alarm Acknowledgement: Not Acknowledged in Alarm, Acknowledged in alarm, Acknowledged Cleared, Not Acknowledged Cleared.
 - d) Alarm Management Controls: Disabling, Shelving, and Silencing alarms.
 - e) Alarm Statistics Reports
 - 4) Process Control Screens (Typical of Each Type)
 - a) Highlight all Operator Control Features on each screen such as clickable targets and setpoint entry
 - b) Example of associated Pop-ups
 - c) Description of the intended use of the screen including control and monitoring capabilities.
 - 5) Examples and descriptions of the following types of screens:
 - a) Power Monitoring
 - b) Control Panel Monitoring
 - c) Network / Communication Monitoring
 - d) Setpoint and Alarm management screens
 - e) Reports
 - c. Identify all clickable actions on the screen and user variable inputs.
- 6. Standard Graphical Objects
 - a. Develop standard graphical objects that match up with standard function blocks for a standardized programming environment.
 - b. Provide descriptions of each Standard Graphical Object including the function block that they are intended to operate with.
 - c. The following is an example of a VFD Pump Function Block and matching Graphical Object.

VFD Pump PLC Object



VFD Pump HMI Object



3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

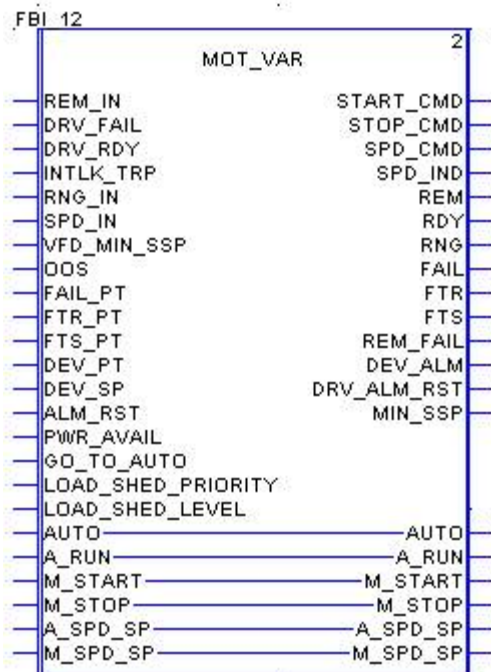
3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

MOT_VAR: Variable Speed Motor Control

- Representation in FBD



- Function Description

This DFB performs the control functions for a typical variable speed motor.

If the REM_IN is High (Motor is in Remote mode), the motor is controlled in Manual or Auto (AUTO In/Out) mode.

In Manual Mode, the motor can be started and stopped from HMI by Manual Start Request (M_Start) and Manual Stop Request (M_Stop) parameters. The speed can be controlled by Manual Speed Setpoint (M_SPD_SP) parameter.

In Auto mode, the motor is started and stopped by Auto Run Request (A_RUN). The speed can be controlled by Auto Speed Setpoint (A_SPD_SP) parameter.

If for some reason, the Motor did not start after activating Start Command (START_CMD) output and Fail-To-Run time delay (Default: 5 sec), the Fail-To-Run (FTR) alarm will be created, the Start Command output will be de-activated, Stop Command (STOP_CMD) will be activated and the motor will be placed in Manual mode.

Also, if the Motor did not stop after activating Stop Command output and Fail To Stop (Default: 5 sec) time delay, the Fail To Run (FTR) alarm will be created and the motor will be placed in Manual mode.

Drive Fail (DRV_FAIL) high input after preset time delay (FAIL_PT, Default: 5 sec), will de-activate the Start Command, activate Stop Command and generate Failure alarm (FAIL).

If the deviation between Speed Command (SPD_CMD) and Speed Feedback (SPD_IN) is higher than Speed Deviation Setpoint (DEV_SP) for more than Alarm Timer Preset Value (DEV_PT, Sec) time delay, the Speed Deviation Alarm (DEV_ALM) alarm will be created.

If the Interlock Trip (INTLK_TRP) goes high or Drive Ready input (DRV_RDY) input goes low, then the Stop Command will be activated and Start Command output will be de-activated.

The transfer from Manual to Auto and Auto to Manual mode is bumpless. Therefore if the mode is changed from Auto to Manual or Manual to Auto, the Speed Command will be ramped to the new Speed Setpoint.

The transfer during loss/restoration of power is bumpless. If the motor was running before the power loss occurred, after restoration of power and if

Current Load Shed Level (LOAD_SHED_LEVEL) is equal or higher than Load Shed Priority level (LOAD_SHED_PRIORITY), then the motor will be restarted.

If the mode is changed from Remote to Local while the motor is running, the Start Command output will be deactivated, the Stop command output will be activated and REM_FAIL alarm will be generated.

The transfer from Local to Remote mode is also bumpless. If the mode is changed from Local to Remote while the engine is running, the Start Command output will be activated.

Out Of Service (OOS) input, will place the Motor in out of service.

Alarm Reset input (ALM_RST) will reset the Alarms.

GO_TO_AUTO parameter defines the state of equipment when the equipment is switched From Local to Remote mode. If the GO_TO_AUTO is set to zero (Go To Manual), the motor shall default to Manual mode during switchover from Local to Remote mode and if the GO_TO_AUTO is set to one (Go To Auto), the motor shall default to Auto mode during switchover from Local to Remote mode

• Description of the input parameters:

Parameter	Data Type	Description	Default Value
REM_IN	BOOL	Remote Input	
DRV_FAIL	BOOL	Drive Fail (Including Overload Trip)	FALSE
DRV_RDY	BOOL	Drive Ready (Including CB Closed)	TRUE
INTLK_TRP	BOOL	Interlock Trip	FALSE
RNG_IN	BOOL	Running Input	
SPD_IN	REAL	Speed Feedback	
VFD_MIN_SSP	REAL	VFD Min Speed Setpoint (%)	0
OOS	BOOL	Out-Of-Service Request	FALSE
FAIL_PT	REAL	Fail Alarm Timer Preset Time (Sec)	5.0
FTR_PT	REAL	Fail-To-Run Timer Preset Time (Sec)	5.0
FTS_PT	REAL	Fail-To-Stop Timer Preset Time (Sec)	5.0
DEV_PT	REAL	Speed Deviation Alarm Preset Time (Sec)	30.0
DEV_SP	REAL	Speed Deviation Setpoint (Percent)	10.0
ALM_RST	BOOL	Alarm Reset	
PWR_AVAIL	BOOL	Power Available	TRUE
GO_TO_AUTO	BOOL	State Of Equipment When The Equipment Is Switched From Local To Remote (0:Man, 1:Auto)	FALSE
LOAD_SHED_PRIORITY	INT	Load Shed Priority (1-6)	1
LOAD_SHED_LEVEL	WORD	Current Load Shed Levels (Bits 0-5)	16#FFFF

• Description of the Output parameters:

Parameter	Data Type	Description
START_CMD	BOOL	Start Command
STOP_CMD	BOOL	Stop Command
SPD_CMD	REAL	Speed Cmd (0-100%)
SPD_IND	REAL	Speed Indicator (0-100%)
REM	BOOL	Remote Status
RDY	BOOL	Ready Status
RNG	BOOL	Running Status
FAIL	BOOL	Failure Alarm
FTR	BOOL	Fail-To-Run Alarm
FTS	BOOL	Fail-To-Stop Alarm
REM_FAIL	BOOL	Switch To Local While Remote Running Command Is Requested Alarm

DEV_ALM	BOOL	Speed Deviation Alarm
DRV_ALM_RST	BOOL	Drive Alarm Reset
MIN_SSP	REAL	Min Speed Setpoint (%)

- **Description of the In/Out parameters:**

Parameter	Data Type	Description
AUTO	BOOL	Auto/Manual Mode (1:Auto, 0:Manual)
A_RUN	BOOL	Auto Run Request
M_START	BOOL	Manual Start Request
M_STOP	BOOL	Manual Stop Request
A_SPD_SP	REAL	Auto Speed Setpoint (%)
M_SPD_SP	REAL	Man Speed Setpoint (%)

SECTION 17710

CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Design, fabrication and assembly of all instrumentation enclosures, control panels and components provided under this contract, including but not limited to:
 - a. Custom built instrumentation and control panels, including all enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
 - b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
 - c. Control components.
 - d. Control panel installation.
- B. Provide all control panels identified in Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
- C. Underwriters Laboratories Inc. (UL):
 - 1. 508 - Standard for Industrial Control Equipment.
 - 2. 508A - Standard for Industrial Control Panel.
 - 3. 913 - Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.
 - 4. 1283 - Standard for Electromagnetic Interference Filters.
 - 5. 1449 - Standard for Surge Protective Devices.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
 - 1. The term "panel" in this Section is interchangeable with the term "enclosure."

1.04 SYSTEM DESCRIPTION

- A. Panel dimensions:

1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer's non-certified information. It is the responsibility of the Contractor or manufacturer to design and size all panels:
 - a. Size panels to provide space for all equipment, wiring, terminations, and other items in the panel, including space for future build out.
 - b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
 - c. Maximum panel depth: 30 inches, unless otherwise indicated.
- B. Structural design:
 1. Completed and installed panel work shall safely withstand seismic requirements at the project site. Enclosures and internal equipment shall be braced to prevent damage from specified forces.

1.05 SUBMITTALS

- A. Provide submittals as specified in the Contract Documents and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide a control panel hardware submittal for each control panel and enclosure being provided on this project, including but not limited to:
 1. Product data:
 - a. Enclosure construction details and NEMA type.
 - b. Manufacturer's literature and specification data sheets for each type of equipment to be installed within or on the panel or enclosure.
 2. Shop drawings:
 - a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
 - 1) Provide draft for review and approval by Engineer. The Engineer has the authority to substantially alter initial panel layouts.
 - b. Complete nameplate engraving schedule.
 - c. Structural details of fabricated panels.
 3. Calculations:
 - a. Provide installation details based on calculated shear and tension forces:
 - 1) Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.
 - b. For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:
 - 1) Weight including panel internal components.
 - 2) Seismic forces and overturning moments.
 - 3) Shear and tension forces in connections.
 - c. Cooling calculations, including but not limited to:
 - 1) Highest expected ambient temperature for the enclosure's location.
 - 2) Internal heat load.
 - 3) Exposure to direct sunlight.
 - 4) Dimensions of the enclosure in inches.
 - 5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.
- C. Seismic design:
 1. Seismic panel construction:

- a. Seismic anchorage: Provide seismic design calculations and installation details for anchorage of all panels, enclosures, consoles, etc. to meet seismic requirements for the project site:
 - 1) Stamped by a Professional Engineer registered in the state of California.
- b. For floor-mounted freestanding panels weighing 200 pounds or more (assembled, including contents), submit calculations, data sheets, and other information to substantiate that panel, base, and framing meet minimum design strength requirements and seismic requirements. Calculations shall be signed and sealed by a Professional Engineer licensed in California.

1.06 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
 - 1. Provide all components and equipment with UL 508 listing.
 - 2. All control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL 508A labeling:
 - a. Non-listed, complex, and unique equipment may be evaluated and approved by a third-party testing agency, with prior approval by the Owner. Provide report documenting the testing standard, specification, method of testing, and that the equipment and materials meet appropriate designated standards or have been tested and found suitable for use in a specified manner.
 - 3. Provide fuses for all equipment that is not UL or UR listed.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. As listed below in the individual component paragraphs.
- B. Provide instruments and other components performing similar functions of the same type, model, or class, and from 1 manufacturer.

2.02 EXISTING PRODUCTS

- A. Provide labor and materials for complete modifications to existing panels as required.
- B. Field cut and refinish existing panel faces to original condition to accommodate installation of new instruments, removal of existing instruments, and fitting of blanks to suit new layouts. New instrument supports shall be provided as required for complete installation.

2.03 MATERIALS

- A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
 - 1. Enclosures shall have the following properties:
 - a. NEMA Type 1: Steel.
 - b. NEMA Type 4: Steel with gasketed door, raintight.
 - c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 is indicated on the Drawings).
 - d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
 - e. NEMA Type 12: Steel with gasketed door, dusttight.
 - f. NEMA Type 7: Cast aluminum.
- B. Bolting material:
 - 1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts, and washers, with unified coarse (UNC) threads.
 - 2. Carriage bolts for attaching end plates.
 - 3. All other bolted joints shall have S.A.E. standard lock washers.

2.04 MANUFACTURED UNITS

- A. Panels/enclosures:
 - 1. Manufacturers: The following or equal:

- a. Pentair/Hoffman.
- b. Rittal.
- c. Tesco.
- 2. Panel assembly:
 - a. General guidelines for panel fabrication include:
 - 1) Continuous welds ground smooth.
 - 2) Exposed surfaces free of burrs and sharp edges.
 - 3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
 - b. Construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	14	14
Up to 57	12	12
57 - 69	12	10
69 - 82	12, except 10 on back	10
82 or more	10	10

- 1) Use heavier sheet metal to meet seismic requirements at the project site or when required due to equipment requirements.
- c. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.
- d. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.
- e. Door construction:
 - 1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
 - 2) Sufficient width to permit door opening without interference with rear projection of flush-mounted instruments.
 - 3) Heavy-gauge stainless steel hinges.
 - 4) For NEMA Type 12, Type 4, and Type 4X, provide oil-resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
 - 5) Gasket installed to seal against roll lip on the enclosure opening.
- f. Latches:
 - 1) For panels, provide each door with a 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods shall be connected to a common door handle, hold doors securely, and form a compressed seal between door and gasket, at the top, side, and bottom.
 - a) Provide padlock for each enclosure with padlock provisions.
 - 2) Include an oiltight key-locking, 3-point latching mechanism on each door:

- a) Provide 2 keys per panel.
 - b) All locks keyed alike.
 - 3) For large NEMA Type 4 and NEMA Type 4X cabinets not available with 3-point latching hardware, provide multiple clips and padlock hasps.
 - g. Panel cut-outs:
 - 1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
 - 2) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.
 - 3) Reinforce around cut-outs with steel angles or flat bars for the following:
 - a) Large panel cutouts; for example, openings for local operator interfaces.
 - b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.
 - 3. In addition to the requirements specified above, the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
 - a. Minimum 14-gauge, Type 304 stainless steel.
 - b. Captive stainless steel cover screws threaded into sealed wells.
 - c. Inside finish: White polyester powder coating.
 - d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
 - e. NEMA Type 4X powder-coated stainless steel enclosures are not an acceptable substitute for stainless steel unless indicated on the Drawings.
 - 4. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
 - a. All enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
 - b. Door hardware: Stainless steel.
 - c. Provide factory installed rain canopy and sun shield for all enclosures with operator interface panels.
 - d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.
- B. Arrangement of components:
- 1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
 - 2. Arrange panel instruments and control devices in a logical configuration, associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
 - 3. Mount internal control components on an internal back panel. Devices may be mounted on the side panel only by special permission from the Engineer.
 - 4. All control-panel-mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.
- C. Overcurrent protection:
- 1. Main overcurrent device:
 - a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange-mounted disconnect handle operating a molded-case circuit breaker and provide a control power transformer for 120-VAC circuits:

- 1) Door-mounted disconnect handles are not acceptable.
- 2) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
- 3) Provide means to defeat the interlock.
- 4) Lockable in the off position.
- b. Control panels supplied with 120 VAC:
 - 1) Provide an internal breaker with the line side terminals covered by a barrier.
 - 2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
2. Selection and ratings of protective devices:
 - a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
 - b. Voltage rating: Not less than the voltage of the application.
 - c. Select current rating and trip characteristics to be suitable for:
 - 1) Maximum normal operating current.
 - 2) Inrush characteristics.
 - 3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
3. Provide a separate protective device for each powered electrical device:
 - a. An individual circuit breaker for each 120-VAC instrument installed within its respective control panel and clearly identified for function.
 - b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
 - 1) Size external fuse to open before any I/O-card-mounted fuses.
 - 2) Individual discrete inputs shall use a 0.5-ampere fuse.
 - c. Control loops can use individual 5-ampere fuse for the loop.
 - d. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.
4. Fuses for 4 to 20 milliamperes signals:
 - a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
 - 1) Label shall not cover or interfere with equipment manufacturer's instructions.
 - b. An individual 1/2-ampere fuse for each 4 to 20 milliamperes analog loop powered from the control panel.
 - c. Provide fuses rated for the voltage and available short-circuit current at which they are applied.
 - d. Manufacturers: The following or equal:
 - 1) Bussmann.
5. Fuse holders:
 - a. Modular type:
 - 1) DIN rail mounting on 35-millimeter rail.
 - 2) Touch-safe design: All connection terminals to be protected against accidental touch.
 - 3) Incorporates blown-fuse indicator.
 - 4) Plug-in style fuse terminals and fuse plugs are not acceptable.
 - b. Provide nameplate identifying each fuse:

- 1) As specified in Section 16075 - Identification for Electrical Systems.
 - c. Manufacturers: The following or equal:
 - 1) Sprecher+Schuh.
 6. Control circuit breakers:
 - a. DIN rail mounting on 35-millimeter rail.
 - b. Manual OPEN-CLOSE toggle switch.
 - c. Rated for 250 VAC.
 - d. Interrupting rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
 - e. Current ratings: As required for the application.
 - f. Provide nameplate identifying each circuit breaker:
 - 1) As specified in Section 16075 - Identification for Electrical Systems.
 - g. Manufacturers: The following or equal:
 - 1) Schneider-Electric.
 - 2) Allen-Bradley.
 7. Electronic circuit protectors:
 - a. Used where equipment is equipped with a NEC Class 2 power supplies requiring 100 watts to 8 amps.
 - b. DIN rail mounting on 35-millimeter rail.
 - c. Rated for 24 VDC.
 - d. 4 channels to feed 4 independent power feeds to separate devices.
 - e. Output current ratings: As required for the application.
 - f. LED input status indication.
 - g. LED failure status of each channel indication.
 - h. Fail contacts.
 - i. Provide nameplate identifying each circuit breaker:
 - 1) As specified in Section 16075 - Identification for Electrical Systems.
 - j. Manufacturers: The following or equal:
 - 1) Schneider-Electric.
 - 2) Allen-Bradley..
- D. Conductors and cables:
1. Power and control wiring:
 - a. Materials: Stranded, soft annealed copper.
 - b. Insulation: 600 volts type MTW.
 - c. Minimum sizes:
 - 1) Primary power distribution: 12 AWG.
 - 2) Secondary power distribution: 14 AWG.
 - 3) Control: 16 AWG.
 - d. Color:
 - 1) AC power (line and load): Black.
 - 2) AC power (neutral): White.
 - 3) AC control: Violet.
 - 4) AC control: Yellow for foreign voltages.
 - 5) DC power and control: Blue.
 - 6) Ground: Green.
 2. Signal cables:
 - a. Materials: Stranded, soft annealed copper.
 - b. Insulation: 600 volts, PVC outer jacket.
 - c. Minimum size: 18 AWG paired triad.
 - d. Overall aluminum shield (tape).
 - e. Copper drain wire.

- f. Color:
 - 1) 2-Conductor:
 - a) Positive (+): Black.
 - b) Negative (-): White and red.
 - 2) 3-Conductor:
 - a) Positive (+): Black.
 - b) Negative (-): Red.
 - c) Signal: White.
- g. Insulate the foil shielding and exposed drain wire for each signal cable with heat-shrink tubing.

E. Conductor identification:

- 1. Identify each conductor and cable with unique wire numbers as specified in Section 16075 - Identification for Electrical Systems.
- 2. Readily identified without twisting the conductor.

F. General wiring requirements:

- 1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
- 2. Install all components in accordance with the manufacturer's instructions included in the listing and labeling.
- 3. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
- 4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
- 5. Provide power surge protection for all control panels.
- 6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
- 7. Provide non-metallic ducts for routing and organization of conductors and cables:
 - a. Provide wiring separation plan.
 - b. Size ducts for ultimate build-out of the panel, or for 20-percent spare, whichever is greater.
 - c. Provide separate ducts for signal and low-voltage wiring from power and 120-VAC control wiring:
 - 1) 120 VAC: Grey colored ducts.
 - 2) 24 VDC: White colored ducts.
- 8. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
 - a. Screw-on cable tie mounts.
 - b. Hammer-on cable-tie mounting clips.
 - c. Fingers of the nonmetallic duct.
- 9. Wire ties:
 - a. No wire ties inside wire duct.
 - b. Use Panduit Cable tie installation tool, with tension control/cutoff.
 - c. Verify cut ends are cut flush filed smooth after installed.
- 10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
- 11. Support panel conductors where necessary to keep them in place.

12. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
 13. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
 - a. Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
 14. The control panel shall be the source of power for all 120-VAC devices interconnected with the control panel including, but not limited to:
 - a. Solenoid valves.
 - b. Instruments both mounted in the control panel and remotely connected to the control panel.
- G. Provide power circuits for all Contractor and Vendor-furnished PLC cabinets in accordance with the PLC and Instrument Power wiring diagrams.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Thermal management:
1. Provide heating, cooling, and dehumidifying devices in order to maintain all instrumentation and control devices to within a range as specified in Section 17050 - Common Work Results for Process Control and Instrumentation.
 2. Air conditioner:
 - a. Provide solid-state cabinet coolers or air conditioning units on all outdoor panels containing electronic components such as local operator interface (LOI) units, panel instruments, programmable logic controllers, or remote I/O.
 - b. Provide filters on intake and exhaust openings.
 - c. Increase panel sizes as needed to accommodate cooling units.
 - d. Enclosure rating: NEMA Type 4X.
 - e. Closed-loop design.
 - f. Power supply: 120 VAC.
 - g. Manufacturers: The following or equal:
 - 1) Kooltronic, GuardianX DP Series.
 - 2) ICEcube, Blade series or IECEx/ATEX for Zone 1 & 2.
 3. Heating:
 - a. Provide all panels located in areas that are not climate controlled with thermostatically controlled strip heaters, except where all of the following conditions apply:
 - 1) The panel is not supplied with 120 VAC power.
 - 2) There are no electronics or moisture-sensitive devices in the enclosure.
 - 3) The panel is smaller than 38 inches high.
 - b. Manufacturers: The following or equal:
 - 1) Chromalox.
 4. Enclosure temperature switch as indicated on the Drawings:
 - a. Provide wall-mounted bimetallic switch transmitter (to measure internal cabinet temperature in all enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.

- b. Sensor and electronic enclosure.
- c. Accuracy: Within 2 degrees Fahrenheit.
- d. Single contact:
 - 1) Manufacturers: The following or equal:
 - a) Hoffman/Pentair ATEMNC.
- e. Dual contact:
 - 1) Manufacturers: The following or equal:
 - a) Hoffman/Pentair ADLTEMP.
- 5. Status relays and discrete inputs for switches, power supplies, and fieldbus devices (if applicable):
 - a. Provide as indicated on the Drawings or as specified.
- 6. Fan ventilation:
 - a. Provide Orion fan:
 - 1) Provide 2 door/cabinet-mounted vent fans for every 72 inches of cabinet width.
 - 2) Provide finger-guard kit.
 - 3) Filter kit with 2 spare filters for each intake fan.
 - 4) Provide bezel and gasket kit.
 - 5) Automatically adjust fan speed depending on remote temperature sensor input.
 - 6) 120 VAC, 60 hertz.
 - 7) NEMA Type 5-15R cord connections.

B. Panel meters:

- 1. Pointer type:
 - a. Suitable for panel mounting.
 - b. Minimum scale length: 3 inches.
 - c. Calibrated in engineering units.
 - d. Accuracy: Within 2 percent of span.
 - e. NEMA Type 4/IP65 sealed front metal bezel.
 - f. Manufacturers: One of the following or equal:
 - 1) Yokogawa.
 - 2) Red Lion.
- 2. Digital process indicators:
 - a. General:
 - 1) Integral provisions for scaling.
 - 2) Scale to process engineering units.
 - 3) Switch-programmable decimal points.
 - 4) NEMA Type 4/IP65 sealed front bezel.
 - b. Current and voltage indicators:
 - 1) 3-1/2-digit minimum.
 - 2) Minimum character height: 0.5 inches.
 - 3) Accuracy:
 - a) AC/DC volts: Within 0.1 percent of reading plus 2 digits.
 - b) DC current: 4 to 20 milliamperes; within 0.1 percent of reading plus 1 digit.
 - c) DC voltage: 0 to 10 volts; within 0.1 percent of reading plus 1 digit.
 - c. Operating voltage: 120 VAC.
 - d. Operating temperature: 0 to 60 degrees Celsius.
 - 1) Manufacturers: One of the following or equal:
 - a) Red Lion.

- b) Action Instruments, Visipak.
 - 3. Digital bar graph meter:
 - a. Self-contained instruments that display process signals directly in engineering units, both in decimal format and as a bar graph display.
 - b. Suitable for panel mounting.
 - c. LED display:
 - 1) Not less than 3 decimal digits.
 - 2) Not less than a 101-segment LED bar graph.
 - d. Input signal:
 - 1) All conventional current loops and voltage control signals.
 - e. Minimum sample rate of once per second.
 - f. Provisions for field-adjustable scaling and/or offset.
 - g. Accuracy shall be within 1 least-significant digit.
 - h. Manufacturers: One of the following or equal:
 - 1) Ametek Dixson.
 - 2) Yokogawa.
 - 3) Weschler Instruments.
 - 4. Counters:
 - a. 6 digits.
 - b. Switch-selectable inputs:
 - 1) Switch contacts.
 - 2) CMOS.
 - 3) TTL.
 - 4) Magnetic pickup.
 - 5) RLC sensors.
 - c. Selectable up/down control via external signal.
 - d. Remote reset.
 - e. Remote inhibit to prevent accumulating counts.
 - f. Programmable to enable or disable front panel reset.
 - g. Non-volatile memory to retain all data upon loss of supply power.
 - h. Sunlight readable.
 - i. Operating temperature: 0 to 50 degrees Celsius.
 - j. Manufacturers: The following or equal:
 - 1) Red Lion, PAX Series.
- C. Pilot devices:
- 1. General:
 - a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
 - b. Size:
 - 1) 30.5 millimeters.
 - c. Heavy duty.
 - d. Pushbuttons:
 - 1) Contacts rated:
 - a) NEMA Type A600.
 - 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
 - e. Selector switches:
 - 1) Contacts rated:
 - a) NEMA Type A600.
 - b) Knob type.

- 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
 - 3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
- f. Pilot lights:
 - 1) Type:
 - a) LED for interior installations.
 - 2) Push to test.
 - 3) Lamp color:
 - a) On/Running/Start: Red.
 - b) Off/Stop: Green.
 - c) Power: White.
 - d) Alarm: Amber.
 - e) Status or normal condition: White.
 - f) Opened: Red.
 - g) Closed: Green.
 - h) Failure: Red.
2. Indoor and outdoor areas:
 - a. NEMA Type 4/13.
 - b. Manufacturers: The following or equal:
 - 1) Schneider-Electric.
 - 2) Allen-Bradley, Type 800T.
3. Corrosive areas:
 - a. NEMA Type 4X.
 - b. Corrosion resistant.
 - c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc.
 - d. Manufacturers: The following or equal:
 - 1) Schneider-Electric.
 - 2) Allen-Bradley Type 800H.
4. Hazardous (Classified) Areas/Class I Division 2:
 - a. NEMA Type 4X.
 - b. Corrosion resistant.
 - c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
 - 1) All contacts contained within a hermetically sealed chamber:
 - a) Pushbuttons.
 - b) Selector switches.
 - c) Push-to-test contacts on pilot lights.
 - 2) UL listed and labeled for Class I Division 2 areas.
 - d. Manufacturers: One of the following or equal:
 - 1) Schneider-Electric.
 - 2) Allen-Bradley, Type 800H.
- D. Potentiometer and slidewire transmitters:
 1. Provide a DC output in proportion to a potentiometer input.
 2. Potentiometer input:
 - a. 100 ohms to 100 K ohms.
 - b. Impedance Greater or equal to 1 M ohms.
 - c. Zero turn-up: 80 percent of full-scale input.
 - d. Span turn-down: 80 percent of full-scale input.
 3. Field-configurable output:

- a. Voltage and current: All conventional current loops and voltage control signals.
 - 4. Accuracy including linearity and hysteresis within 0.1 percent maximum at 25 degrees Celsius.
 - 5. Operating temperature: 0 to 55 degrees Celsius.
 - 6. Supply power: 9 to 30 VDC.
 - 7. Manufacturers: The following or equal:
 - a. Schneider-Electric.
 - b. Allen-Bradley.
- E. Signal isolators and converters:
 - 1. Furnish signal isolators that provide complete isolation of input, output, and power input:
 - a. Minimum isolation level: 1.0 kilovolts AC/50 hertz for at least 1 minute.
 - b. Adjustable span and zero.
 - c. Accuracy: Within 1.0 percent of span.
 - d. Ambient temperature range: -20 to +65 degrees Celsius.
 - 2. Manufacturers: The following or equal:
 - a. Phoenix Contact.
 - b. Moore Industries.
- F. Relays:
 - 1. General:
 - a. For all types of 120-VAC relays, provide surge protection across the coil of each relay.
 - b. For all types of 24-VDC relays, provide a free-wheeling diode across the coil of each relay.
 - c. For plug in type relays, provide a relay base from the same manufacturer as the relay manufacturer.
 - 2. General purpose:
 - a. Magnetic control relays.
 - b. NEMA ratings:
 - 1) 300 volts.
 - 2) 10 Amps thermal continuous test current.
 - 3) 60 Amps make.
 - 4) 6 Amps break.
 - c. Plug-in type.
 - d. LED indication for energization status.
 - e. Coil voltages: As required for the application.
 - f. Minimum poles: DPDT.
 - g. Touch-safe design: All connection terminals to be protected against accidental touch.
 - h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
 - i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
 - j. Relays with screw-type socket terminals.
 - k. Provide additional (slave/interposing) relays when the following occurs:
 - 1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
 - 2) Higher contact rating is required in order to interface with starter circuits or other equipment.

- l. DIN rail mounting on 35-millimeter rail.
 - m. Ice-cube-type relays with retainer clips to secure relay in socket.
 - n. Integrated label holder for device labeling.
 - o. Manufacturers: The following or equal:
 - 1) Schneider-Electric.
 - 2) Allen-Bradley.
3. Terminal block relays:
- a. Magnetic control relays.
 - b. For use as an interposing relay for PLC based discrete I/O signals.
 - c. NEMA ratings:
 - 1) 250 volts.
 - 2) 6 Amps continuous.
 - 3) 1,500 volt-amperes make.
 - d. Plug-in type.
 - e. LED indication for energization status.
 - f. Coil voltages: As required for the application.
 - g. Minimum poles: SPDT.
 - h. Touch-safe design: All connection terminals to be protected against accidental touch.
 - i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
 - j. Relays with screw-type socket terminals.
 - k. DIN rail mounting on 35-millimeter rail.
 - l. Integrated label holder for device labeling.
 - m. Manufacturer: The following or equal:
 - 1) Phoenix Contact.
4. Latching:
- a. Magnetic-latching control relays.
 - b. NEMA ratings:
 - 1) 300 volts.
 - 2) 5 Amps continuous.
 - 3) 360 volt-amperes make.
 - 4) 320 volt-amperes break.
 - c. Plug-in type.
 - d. DIN rail mounting on 35-millimeter rail.
 - e. Coil voltage: As required for the application.
 - f. Minimum poles: 2 PDT; as required for the application. Plus 1 spare pole.
 - g. Touch-safe design: All connection terminals to be protected against accidental touch.
 - h. Clear cover for visual inspection.
 - i. Provide retainer clip to secure relay in socket.
 - j. Manufacturers: The following or equal:
 - 1) Schneider-Electric.
 - 2) Allen-Bradley.
5. Time delay:
- a. Provide time-delay relays to control contact transition time.
 - b. Contact rating:
 - 1) 240 volts.
 - 2) 10 Amps continuous.
 - 3) 3,600 volt-amperes make.

- 4) 360 volt-amperes break.
- c. Coil voltage: As required for the application.
- d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off-delay:
 - 1) For off-delay, use true power-off time-delay relays. Where the required timing range exceeds capability of the off-delay relay use, signal off-delay where power loss will not cause undesirable operation or pneumatic time-delay relays.
- e. Minimum poles: 2 PDT.
- f. Units include adjustable dial with graduated scale covering the time range in each case.
- g. Minimum timing range: 0.1 seconds to 10 minutes, or as required for the application.
- h. Manufacturers: The following or equal:
 - 1) Schneider-Electric.
 - 2) Allen-Bradley.

G. Terminal blocks:

- 1. DIN rail mounting on 35-millimeter rail.
- 2. Suitable for specified AWG wire.
- 3. Rated for 15 amperes at 600 volts.
- 4. Screw terminal type.
- 5. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
- 6. Finger-safe protection for all terminals for conductors.
- 7. Construction: Polyamide insulation material capable of withstanding temperature extremes from - 40 to 105 degrees Celsius.
- 8. Terminals: Plainly identified to correspond with markings on the diagrams:
 - a. Permanent machine-printed terminal identification.
- 9. Disconnect-type field signal conductor terminals with socket/screw for testing.
- 10. Identify terminals suitable for use with more than 1 conductor.
- 11. Position:
 - a. So that the internal and external wiring does not cross.
 - b. To provide unobstructed access to the terminals and their conductors.
- 12. Provide minimum 25-percent spare terminals.
- 13. Manufacturers: One of the following or equal:
 - a. Allen-Bradley.
 - b. Weidmuller.

H. Wire duct:

- 1. Provide flame retardant plastic wiring duct, slotted with dust cover.
- 2. Type:
 - a. Wide slot.
 - b. Narrow slot.
 - c. Round hole.
- 3. Manufacturers: The following or equal:
 - a. Panduit.
 - b. Phoenix Contact.
 - c. Thomas & Betts.

I. Din rail:

1. Perforated steel.
2. 35 mm width.
3. 15 mm deep.
4. Provide 2-inch offset using one of the following:
 - a. Offset brackets.
 - b. Preformed standoff Din Rail Channel.

J. Surge protection devices:

1. 120-volt control power for panels:
 - a. Panels without a UPS:
 - 1) Provide surge protection device (SPD) for panel power entrances:
 - a) Nominal 120-VAC with a nominal clamping voltage of 200 volts.
 - b) Non-faulting and non-interrupting design.
 - c) A response time of not more than 5 nanoseconds.
 - 2) Control panel power system level protection, non-UPS powered:
 - a) Designed to withstand a maximum 10-kA test current of an 8/20 μ s waveform according to IEEE C62.41.1 Category C Area.
 - b) For panels receiving power at 120 VAC, provide surge protection at secondary of main circuit breaker.
 - c) Provide both normal mode noise protection (line to neutral) and common mode (neutral to ground) surge protection.
 - d) DIN rail mounting.
 - e) Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:
 - (1) Gastight connections.
 - (2) The terminal block: Fabricated of non-ferrous, non-corrosive materials.
 - f) Visual status indication of MOV status on the input and output circuits.
 - g) Dry contact rated for at least 250 VAC, 1 Amp for remote status indication.
 - h) Meeting the following requirements:
 - (1) Response time: Less than or equal to 100 ns.
 - (2) Attenuation: Greater than or equal to -40 dB at 100 kilovolt-hertz as determined by a standard 50-ohm insertion test.
 - (3) Safety approvals:
 - (a) UL 1283 (EMI/RFI Filter).
 - (b) UL 1449 2nd Edition.
 - i) Manufacturers: The following or equal:
 - (1) Schneider Electric:
 - (a) ASCO, Model 277 (formerly Islatrol IE Series) Surge Protection Device.
 - b. Panels with a UPS:
 - 1) Provide surge protection on the control power source at each panel containing power supplies, or electronic components including PLCs, I/O, HMI, and digital meters.
 - 2) Location:
 - a) For panels with a UPS, install surge protection ahead of UPS and maintenance bypass switch.
 - (1) Surge protection is not required for 120-VAC circuits that are only used for panel lights and receptacles.

- 3) Maximum Continuous Operating Voltage: 150 VAC.
 - 4) Surge capability (8/20 μ s wave): 10 kA.
 - 5) Peak let-through: 620V L-N, 850V L-G.
 - 6) Manufacturers: One of the following or equal:
 - a) Phoenix Contact, Plugtrab SEC Series.
 - b) MTL Surge Technologies, MA15 Series.
 - c. For panels receiving power at 480 VAC, provide surge protection on the 120-VAC control power transformer secondary.
 2. Instrument, data, and signal line protectors (traditional I/O) - panel mounted:
 - a. Surge protection minimum requirements: Withstand a 10-kA test current of an 8/20 μ s waveform in accordance with IEEE C62.41.1 Category C Area.
 - b. DIN rail mounting on 35-millimeter rail (except field-mounted SPDs).
 - c. SPDs consisting of 2 parts:
 - 1) A base terminal block.
 - 2) A plug protection module:
 - a) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
 - b) Base and plug coded to accept only the correct voltage plug.
 - d. SPD:
 - 1) Manufacturers: One of the following or equal:
 - a) Phoenix Contact, Plugtrab SEC Series.
 - b) Bournes, Series 1800.
 3. Instrument, data, and signal line protectors (traditional I/O) - field mounted:
 - a. Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20 μ s waveform in accordance with IEEE C62.41.1 Category C Area.
 - b. Manufacturers: One of the following or equal:
 - 1) Phoenix Contact, Surgetrab Series.
 - 2) MTL, TP48 Series.
- K. Horns and beacons:
1. Beacons/horn combination units:
 - a. Manufacturers: The following or equal:
 - 1) Edwards, Multi-Status LED 108i with tone module.
 - b. LED Colors: Red, Green, and Amber.
 - c. Power: 120VAC.
 - d. Provide accessories such as pipe mount flange, pipe extensions, corner mount brackets, or wall mount brackets as needed.
 - e. Horn rated 80 dB minimum at 10 feet.
 2. Dedicated beacon unit:
 - a. Manufacturers: One of the following or equal:
 - 1) Federal Signal Corp., Starfire Series.
 - 2) Allen-Bradley, 855 B *-* 10 Series.
 - 3) Edwards, 102 Series.
 3. Dedicated horn unit:
 - a. Electromechanical:
 - 1) Manufacturers: One of the following or equal:
 - a) Federal Signal, 350 or 31X Series.
 - b) Edwards, 878EX or 879EX Series.
 - b. Electronic:
 - 1) Manufacturers: One of the following or equal:

- a) Federal Signal, 300GCX or 300X Series.
 - b) Allen-Bradley, 855H or 855XH Series.
 - c) Edwards, 5530M or 5533MD Series.
- c. Rated for 80 dB minimum at 10 feet.

L. Power supplies:

1. Design power supply system so that either the primary or backup supply can be removed, repaired or replaced, and returned to service without disrupting the system operation.
2. Convert 120 VAC to 24-volt DC or other DC voltages required or as required for the application.
3. Provide redundant backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure in either a 1+1 or N+1 configuration as required:
 - a. Provide automatic switchover upon module failure.
 - b. Alarm contacts monitored by the PLC.
5. Provide protective isolation between power supply units either by means of Diodes, Diode Modules, MOSFET Modules, or use power supplies with built in redundancy. Power supplies with built in redundancy must actively isolate each power supply and be designed as such.
6. Sized to provide 40-percent excess rated capacity.
7. UL 508C listed to allow full-rated output without de-rating.
8. Provide fuse or short-circuit protection.
9. Provide a minimum of 1 set of dry contacts for each power supply configured to change state on failure for monitoring and signaling purposes.
10. Output regulation: Within 0.05 percent for a 10-percent line change or a 50-percent load change.
11. Operating temperature range: 0 to 60 degrees Celsius.
12. Touch-safe design: All connection terminals to be protected against accidental touch.
13. DIN rail mounting on 35-millimeter rail:
 - a. Mount the power supply in the proper orientation as recommended by the manufacturer to ensure adequate thermal dispersion without derating the power supply.
14. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
15. Manufacturers: One of the following or equal:
 - a. Schneider-Electric.
 - b. Allen-Bradley.
 - c. Phoenix Contact.

M. Intrinsic safety barriers:

1. Transformer isolated barrier:
 - a. Containing a transformer to provide complete:
 - 1) Isolation between the safe and hazardous areas for loop-powered devices.
 - 2) 3-way isolation between the safe area, hazardous area, and power supply powered devices.
 - b. Resistor for current limitation.
 - c. Fuses for short-circuit protection.

- d. Provide barriers with pluggable connectors that are coded for easy replacement.
- e. Transmission error shall be less than or equal to 0.1 percent of full-scale.
- f. DIN rail mounting on 35-millimeter rail.
- g. Approvals:
 - 1) FM.
 - 2) UL 913.
- 2. Types:
 - a. Switch isolators:
 - 1) Designed and approved for use with discrete inputs.
 - 2) Supply power: 20 to 30 VDC.
 - 3) Output to track input.
 - 4) LED in the cover to indicate the status of the input.
 - 5) Selector switch to change the logic of the input.
 - 6) Input: Dry contact.
 - 7) Output: SPDT relay.
 - b. Transmitter and converters for use with 4- to 20-milliampere signals without Hart® communications capability:
 - 1) Designed and approved for use with 4- to 20-milliampere analog signals.
 - 2) Designed for powering 2- and/or 3-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
 - 3) Supply voltage: 20 to 30 VDC.
 - c. Transmitter and converters for use with 4- to 20-milliampere signals with Hart® communications capability:
 - 1) Designed and approved for use with 4- to 20-milliampere analog signals.
 - 2) Designed for powering 2- and/or 3-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
 - 3) Transfer digital signals from the hazardous area to the safe area.
 - 4) Complete bi-directional communication between a smart transmitter located in the field and the suitable equipment located in the safe area.
 - 5) Supply voltage: 20 to 30 VDC.
- 3. Manufacturers: The following or equal:
 - a. Pepperl + Fuchs.
- N. Limit switches:
 - 1. NEMA Type 4X.
 - 2. AC contact rating 120 volts, 10 A.
 - 3. DC contact rating 125 volts, 0.4 A.
 - 4. Provide robust actuation mechanism not prone to degradation.
 - 5. Provide complete actuator mechanism with all required hardware.
 - 6. Allows for contact opening even during contact weld condition.
 - 7. UL approved.
 - 8. Operating temperature range: -18 to +110 degrees Celsius (0 to 230 degrees Fahrenheit).
 - 9. Manufacturers: The following or equal:
 - a. Schneider-Electric.
 - b. Allen-Bradley.

- O. Current switches:
 - 1. Operate from 120-VAC supply voltage.
 - 2. 1 normally open and normally closed contacts.
 - 3. Adjustable current setting.
 - 4. Manufacturers: The following or equal:
 - a. Schneider-Electric, Zelio®, RM35.
 - b. Phoenix Contact, EMD Series.
- P. Current transmitters:
 - 1. Input current range: As indicated on Drawings.
 - 2. Output: 4-20 mA.
 - 3. Operate from 24 VDC supply voltage.
 - 4. Output overload protected.
 - 5. Accuracy: Within 0.5 percent Full-Scale.
 - 6. Ripple and Noise: 1 percent Max., peak to peak.
 - 7. Frequency: 50/60 hertz.
 - 8. Manufacturer:
 - a. Phoenix Contact: Mini Analog Pro Series.
 - b. CR Magnetics: CR4320 series.

2.07 ACCESSORIES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide panels with an inside protective pocket to hold the panel drawings. Ship panels with 1 copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.
- C. Provide 15-inch floor stands or legs where needed or as indicated on the Drawings.
- D. Provide a folding shelf for enclosures that contain programmable controllers. The shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.
- E. Provide nameplate to each panel as indicated on the Drawings:
 - 1. Provide as specified in Section 16075 - Identification for Electrical Systems on all internal and external instruments and devices.
 - 2. Provide a nameplate with the following markings that is plainly visible after installation:
 - a. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
 - b. Supply voltage, phase, frequency, and full-load current.
 - c. Power source or circuit ID.
 - d. Short-circuit current rating of the panel based on one of the following:
 - 1) Short-circuit current rating of a listed and labeled assembly.
 - 2) Short-circuit current rating established utilizing an approved method.
- F. Provide a window kit where indicated on the Drawings or where a transmitter with display is mounted inside a control panel. The window shall meet the following requirements:
 - 1. Safety plate glass.

2. Secured by rubber locking seal.
 3. Allow full viewing of devices issuing visual process data or diagnostics.
- G. Lighting:
1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
 - a. Covered or guarded.
 - b. Provide On-Off door-activated switches where indicated on the Drawings.
 - c. 120-volt, single-phase, 15-amp style plug.
 - d. Provide 4,000 K, 900 Lumens - LED fixture.
 - 1) Provide additional fixtures for every 36 inches of width.
- H. Receptacles:
1. Provide 1 duplex receptacle located every 4 feet of enclosure width, spaced evenly along the back mounting panels.
 2. GFCI, 120-volt, single-phase, 15-amp style plug.
 3. Provide circuit breaker or fuse to limit receptacle draw to 5 amperes.
- I. Grounding:
1. Provide the following:
 - a. Grounding strap between enclosure doors and the enclosure.
 - b. Equipment grounding conductor terminals.
 - c. Provide equipment ground bus with lugs for connection of all equipment grounding wires.
 - d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding bus.
 2. Identify equipment grounding conductor terminals with the word "GROUND," the letters "GND," the letter "G," or the color green.
 3. Signal (24 VDC) grounding: Terminate each drain wire of a signal (shielded) cable to a unique grounding terminal block, or common ground bus at the end of the cable as shown on the Loop Drawings.
 4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
 5. Design so that removing a device does not interrupt the continuity of the equipment-grounding circuit.
 6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
 7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
 8. Connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
 9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
 10. Bond together all remote and local control panels, processor racks, and conductive enclosures of power supplies and connect to the equipment-grounding circuit to provide a common ground reference.
- J. Provide sunshades and insulation for all outdoor installations.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finishes:

1. Metallic (non-stainless):
 - a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.
 - b. Scratches or blemishes shall be filled before finishing. One coat of zinc phosphate shall be applied per the manufacturer's recommended dry-film thickness and allowed to dry before applying the finish coat.
 - c. Finish coat shall be a baked polyester-urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
 - d. Exterior of enclosures located outdoors shall be UV-resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
2. Stainless steel:
 - a. Stainless enclosures shall be provided with a Number 4 brushed finish - not painted.

B. Colors:

1. Exterior color of panels mounted indoors shall be manufacturer's standard light gray.
2. Exterior of panels mounted outdoors shall be manufacturer's standard white.
3. Panel interiors shall be manufacturer's standard white.

2.11 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install enclosures so that their surfaces are plumb and level within 1/8-inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.
- B. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the project site.
- C. Provide floor stand kits for wall-mounted enclosures larger than 48 inches high.
- D. Provide 3-1/2-inch high concrete housekeeping pads for freestanding enclosures.

- E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
 - 1. Undercoat floor-mounted panels.
- F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.
- G. All holes for field conduits, etc. shall be cut in the field. There shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or mis-cut holes shall require that the entire enclosure be replaced.
- H. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the Conduit Schedule, but shall be shown on the Loop Drawings prepared by the Contractor.
- I. Provide individually fused analog input module points with blown-fuse indicator lights, mounted external of the module on the output terminal strip.
- J. Side panels:
 - 1. Side panels shall be kept free off all control equipment and devices. Any deviation must be sent to the engineer in writing asking for a deviation.

3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17720

CONTROL SYSTEMS: PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Programmable logic controller (PLC) based control systems hardware.
 - 2. Development software to be used with the specified PLC hardware.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Institute of Electrical and Electronics Engineers (IEEE).

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
 - 1. CPU: Central processing unit.
 - 2. I/O: Input/Output.
- C. Specific definitions:
 - 1. Development operating software: The software provided by the PLC manufacturer for use in programming the PLC.
 - 2. Application software: The software that is programmed specifically for the Project.

1.04 SYSTEM DESCRIPTION

- A. Provide all PLC hardware as indicated on the Drawings and as specified in this Section.

1.05 SUBMITTALS

- A. Furnish submittals as specified in the Contract Documents and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. CPU:
 - a. Processor type.
 - b. Processor speed.
 - c. Memory.
 - d. Internal processor battery backup time.
 - 2. I/O modules:

- a. Type.
 - b. Standard wiring diagram.
- C. Calculations:
 - 1. Submit calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use PLC manufacturer's calculation or estimating worksheet.
 - 2. Submit calculations to verify that spare I/O requirements of this Section are met.
 - 3. Submit calculations to verify that PLC power supply requirements of this Section are met.
- D. Product data:
 - 1. Programming languages.
 - 2. Operating system requirements.
- E. Control logic:
 - 1. Fully annotated copy of programmed PLC logic.
 - 2. Cross-referenced index of all PLC registers or points.
- F. Provide application software for the specific Project process requirements.
 - 1. Fully annotated copy of programmed PLC logic in its native format.
 - 2. Cross-referenced index of all PLC registers or points.

1.06 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.
- C. Additional requirements:
 - 1. Provide PLC system components by a single manufacturer:
 - a. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.
 - 2. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.
 - 3. All PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects, and produced by manufacturers regularly engaged in the manufacture of these products.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. In addition to the spare parts requirements specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems
 - 1. CPU: 1 spare for each type of CPU in the system.
 - 2. I/O cards: 3 spares for each type of I/O card in the system.
 - 3. Power supplies: 2 spares for every power supply in the system.
 - 4. Network/communications cards: 1 spare for every network or communications card in the system.
 - 5. Remote adapter: 1 spare for every remote adaptor in the system.
 - 6. Chassis: 1 spare for each chassis size in the system.
- C. Installed spare requirements:
 - 1. I/O points:
 - a. Provide total of 25 percent spare I/O capacity for each type of I/O at every PLC and remote inputs and outputs (RIO).
 - b. Wire all spare I/O points to field terminal blocks in the same enclosure the PLC resides in.
 - 2. PLC backplane capacity:
 - a. Provide 25-percent or 3 spare backplane slots, whichever is greater, in all racks containing I/O.
 - 3. PLC memory:
 - a. Provide 50-percent spare program volatile memory.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following, no equal:
 - 1. Schneider-Electric Modicon:
 - a. M580.
 - b. M340.

- B. The PLC programming software system shall be manufactured by PLC hardware manufacturer:
 - 1. Modicon:
 - a. Unity Pro, coordinate revision and build used with the Owner.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. Programmable logic controller:
 - 1. Construction:
 - a. Furnish plug-in modular system.
 - b. Provide PLCs capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
 - 1) Temperature: 0 to 60 degrees Celsius.
 - 2) RFI: 80 to 1,000 MHz.
 - 3) Vibration: 10 to 500 hertz.
 - 4) Humidity: 0 to 95 percent.
 - c. Provide internal power supplies designed to protect against overvoltage and frequency distortion characteristics frequently encountered with the local power utility.
 - d. Design the PLC system to function as a standalone unit that performs all of the control functions described in this Section completely independent from the functions of the HMI system PC-based operator interfaces:
 - 1) Failure of the HMI system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
 - 2. CPU:
 - a. Configure each CPU so that it contains all the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
 - b. Capable of interfacing with all discrete inputs, analog inputs, discrete outputs, analog outputs, and communication cards to meet the specified requirements.
 - c. Capable of supporting and implementing closed-loop floating-point math and PID control that is directly integrated into the CPU control program.
 - 3. Memory:
 - a. Non-volatile memory: On-board complementary metal-oxide-semiconductor (CMOS), electrically erasable programmable read-only memory (EEPROM), PCMCIA, compact flash card, or SD card.
 - b. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
 - 1) Reserve capacity:
 - a) Totally free from any system use.
 - 2) Programmed in a multi-mode configuration with multiple series or parallel contacts, function blocks, counters, timers, and arithmetic functions.
 - 4. Programming:

5. PLC power supply:
 - a. Input: 120 VAC.
 - b. Mounted in the PLC housing or as indicated on the Drawings.
 - c. Sized to power all modules mounted in that housing including an average module load for any empty housing slots plus 50 percent above that total.
6. PLC input/output, I/O modules:
 - a. General:
 - 1) Compatible with all of the PLCs being furnished under the contract and by the same manufacturer as the PLCs.
 - 2) Provide I/O modules that:
 - a) Isolate in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
 - b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
 - c) Accept dual-ended inputs.
 - 3) The use of common grounds between I/O points is not acceptable.
 - 4) Provide modules that are removable without having to disconnect wiring terminals:
 - a) Utilize a swing-arm or plug-in wiring connector.
 - 5) Provide at each PLC the I/O modules for the following:
 - a) Designated future I/O points contained in the I/O Lists and/or shown on the P&IDs, control schematics, or described in the control strategies.
 - b) Installed spare capacity in accordance with the requirements of this Section.
 - c) Wire all spares provided to the field terminal strip.
 - 6) Condition, filter, and check input signals for instrument limit conditions.
 - 7) Filter, scale, and linearize the raw signal into an engineering-units-based measurement.
 - 8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
 - 9) Provide external fuses mounted on the field connection terminal block for all discrete input, discrete output, and analog input I/O points.
 - 10) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.
 - b. Discrete input modules:
 - 1) Defined as contact closure inputs from devices external to the input module.
 - 2) Provide inputs that are optically isolated from low-energy common-mode transients to 1,500 volts peak from users wiring or other I/O modules.
 - 3) Individually isolated inputs.
 - 4) With LEDs to indicate status of each discrete input.
 - 1) Input voltage: 24VDC.
 - 2) Provide input module points that are individually fused with blown-fuse indicator lights, mounted external of the module on the output terminal strip:

- a) Coordinate external fuse size with the protection located on the module, so that the external fuse opens first under a fault condition.
 - c. Discrete output modules:
 - 1) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
 - a) Triac outputs may be used, with the permission of the Engineer. Care must be used in applying this type of module to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.
 - 2) Optically isolated from inductively generated, normal mode and low-energy common-mode transients to 1,500 volts peak.
 - 3) LEDs to indicate status of each output point.
 - 4) Output voltage: 24VDC.
 - 5) Individually isolated outputs.
 - d. Analog input modules:
 - 1) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
 - 2) Analog-to-digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
 - 3) The analog-to-digital conversion updated with each scan of the processor.
 - 4) Individually isolated each input.
 - 5) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.
 - e. Analog output modules:
 - 1) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
 - 2) Individual isolated output points each rated for loads of up to 1,200 ohms.
- 7. Communications modules:
 - a. Remote I/O adapter module:
 - 1) For any PLC location requiring more than 1 housing to mount all of the I/O modules or that is identified as a RIO, provide the appropriate remote I/O adapter module for communication with the secondary housing(s).
 - a) New: BMXCRA312-0 adaptor module for Modicon X80.
 - b) Retrofitted: 140CRA31200 adaptor module for Quantum.
 - 2) Install the RIO adapter module in the PLC backplane and the RIO backplane.
 - 3) Provide adapter modules that support all available types of I/O modules required.
 - 4) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
 - 5) Complete diagnostic LEDs.
 - b. Network communications modules:
 - 1) General:
 - a) Install communications modules in the PLC backplane.
 - 2) Ethernet:
 - a) Ports: 2.
 - b) Communication rate: 100 Mbit/s.

- 3) Modbus:
 - a) Ports: 2.
 - b) Each port individually configurable as Modbus Master or Slave.
 - 4) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
 8. PLC backplane housing:
 - a. Mount the PLC power supply, CPU, communications module, and I/O modules in a suitable standard PLC backplane or housing.
 - b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
 - c. Provide a blank slot filler module for each spare slot.
- B. HMI system interface:
 1. As specified in Section 17733 - Control Systems: Network Materials.
- C. PLC programming software:
 1. Furnish operating software capable of monitoring and/or controlling the PLCs via the PLC data network:
 - a. Contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables.
 - b. Monitor devices at each drop on the PLC data network for proper communications.
 - c. Provide the ability to program all PLCs on the PLC data network from the Engineer's console.
 2. PLC programming laptop/desktop operating system:
 - a. Microsoft Windows 10.
 3. The PLC programming software shall be suitable for the PLCs specified above.
 4. PLC programming software for all programming, monitoring, searching, and editing:
 - a. Usable both on-line, while connected to the PLC, and off-line.
 - b. The operating software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical function blocks.
 - c. Capable of disabling/forcing all inputs, outputs, and coils to simulate the elements of the ladder logic; forced elements shall be identifiable by means of color change.
 - d. Include a search capability to locate any address or element and its program location.
 - e. Display at the EC, PLC status information, such as faults and communication errors and amount of memory remaining.
 5. The PLC programming software shall support the following programming languages:
 - a. Ladder Diagram.
 6. Generate a PLC program printout, which is fully documented, through the PLC programming software:
 - a. Fully documented program listings include, as a minimum, appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes on an individual line-by-line basis.

- b. Include a sufficient embedded comment for every rung of the program explaining the control function accomplished in said rung.
 - c. Use a mnemonic associated with each contact, coil, etc. that describes its function.
 - d. Utilize the tag and loop identification as contained in the P&IDs:
 - 1) If additional internal coils, timers, etc. are used for a loop, they shall contain the loop number.
 - e. Provide a cross-reference report of program addresses.
- 7. Software functions automatically without operator intervention, except as required to establish file names and similar information:
 - a. Furnish the operating system software that is the standard uncorrupted product of the PLC manufacturer with the following minimum functions:
 - 1) Respond to demands from a program request.
 - 2) Dynamic allocation of the resources available in the PLC. These resources include main memory usage, computation time, peripheral usage, and I/O channel usage.
 - 3) Allotment of system resources based on task priority levels such that a logical allocation of resources and suitable response times are ensured.
 - 4) Queuing of requests in order of priority if one or more requested resources are unavailable.
 - 5) Resolution of contending requests for the same resource in accordance with priority.
 - 6) Service requests for execution of one program by another.
 - 7) Transfer data between programs as requested.
 - 8) Management of all information transfers to and from peripheral devices.
 - 9) Control and recovery from all program fault conditions.
 - 10) Diagnose and report real-time hardware device errors.
- 8. Program execution:
 - a. Application software - program execution scheduled on a priority basis:
 - 1) A multilevel priority interrupt structure is required.
 - 2) Enter into a list of pending programs a program interrupted by a higher priority program:
 - a) Resume its execution once it becomes the currently highest priority program.
 - 3) Schedule periodic programs.
 - 4) Base the allocation of resources to a time-scheduled program on its relative priority and the availability of resources.
- 9. Start-up and restart:
 - a. Provide software that initializes and brings a PLC or any microprocessor-based hardware unit from an inactive condition to a state of operational readiness.
 - b. Initialization:
 - 1) Determination of system status before start-up of initializing operating system software and initializing application software.
 - 2) Loading of all memory-resident software, initializing timers, counters, and queues, and initialization of all dynamic database values.
- 10. Shutdown:
 - a. Where possible, provide orderly shutdown capability for shutdowns resulting from equipment failure, including other PLC processor failures, primary power failure, or a manually entered shutdown command.

- b. Upon loss of primary power, a high-priority hardware interrupt initiates software for an immediate, orderly shutdown.
 - c. Hardware is quickly and automatically commanded to a secure state in response to shutdown command or malfunction.
 - d. Alarm PLC failure at the operator interface level.
11. Diagnostics:
- a. Furnish diagnostic programs with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures.
 - b. Use the manufacturer's standard diagnostic routines as much as possible.
 - c. Furnish diagnostic software and test programs for each significant component in the control system.
 - d. As a minimum, provide diagnostic routines to test for power supply, central processing unit, memory, communications, and I/O bus failures.
12. Calendar/time program:
- a. The calendar/time program to update the second, minute, hour, day, month, and year and transfer accurate time and date information to all system-level and application software.
 - b. Variations in the number of days in each month and in leap years must be handled automatically by the program.
 - c. The operator must be able to set or correct the time and date from any operator interface, only at the highest security level.
13. Algorithms:
- a. Implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete data.
 - b. Algorithms must be capable of outputting positional or incremental control outputs or providing the product of calculations.
 - c. Algorithms must include alarm checks where appropriate.
 - d. Provide, as a minimum, the following types of algorithms:
 - 1) Performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.
 - 2) A switch algorithm, which reads the current and value from its input address and stores it as the value of its output address. 2 types of switches shall be accommodated: 2 outputs with 1 input and 1 output with 2 inputs.
 - 3) A 3-mode proportional-integral-derivative, PID, controller algorithm, with each of the 3 modes independently adjustable, supports both direct and reverse-acting modes.
 - 4) Lead, lag, dead time, and ratio compensators.
 - 5) Integration and totalization of analog process variables.
14. Furnish a comprehensive database for the analog inputs, calculated values, control modules, and outputs:
- a. In addition, provide spare database points for future expansion.
15. One integrated database can be utilized for all types of analog points or separate databases for each type; in either case, the database for each point must include all specified aspects.
16. All portions of the database must be available for use by the display, report, and other specified software modules.
17. All of the data fields and functions specified below must be part of the point definition database at the operator interface. Provide the capability to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and

modification must include all of the features and functions defined below. The analog database software must support the following functions and attributes:

- a. Analog input signal types:
 - 1) Provide software at the remote terminal units (RTUs) and PLCs to read variable voltage/current signals and pulse duration/frequency type analog input signals.
- b. Input accuracy:
 - 1) Inputs must be read with an accuracy of within 0.05-percent full-scale or better.
 - 2) Data conversion errors must be less than 0.05-percent full-scale.
 - 3) Pulse accumulation error less than or equal to 1 count of actual input count at a scan rate of once per minute.
 - 4) Maintain for a minimum of 1 year the system accuracy stated above without adjustments.
- c. Blocking:
 - 1) Provide mechanisms to inhibit or block the scanning and/or processing of any analog input through the operator interface.
 - 2) For any input so blocked, the operator may manually enter a value to be used as the input value.
- d. Filtering:
 - 1) For each analog input, provide a first order lag digital filter with an adjustable filter factor.
- e. Linearizing:
 - 1) Where analog inputs require square root extraction or other linearization, provide a mechanism to condition the filtered data before the process of scaling and zero suppression takes place.
- f. Calculated values:
 - 1) Provide means to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated values, constants, etc.
 - 2) These values must be handled the same as real inputs in terms of record-keeping, alarming, etc.
- g. Scaling and zero suppression:
 - 1) Provide a conversion program to convert input values into engineering units in a floating-point format.
- h. Alarms:
 - 1) Provide an alarm program to check all analog variables against high-high, high, low, and low-low alarm limits.
 - 2) When an analog value exceeds a set limit, it must be reported as an alarm based on individually set priority level for each alarm point.
 - 3) Provide an adjustable hysteresis band in order to prevent excessive alarms when a variable is hovering around an alarm limit.
 - 4) Must be possible to inhibit alarms based on external events, e.g., lock-out low pump flow alarm when the pump is off.
- i. Averages:
 - 1) Provide a program to calculate and store hourly, daily, and monthly averages of analog variables.
 - 2) Continuously compute averages, e.g., the average for the current period to the present point in time must be stored in memory and available for use in displays, etc.
 - 3) Update hourly averages each minute or at the polling interval for the selected variable.

- 4) Update daily averages at least once each hour and calculate using the results of the hourly averages.
- 5) Update monthly averages at least once each day and calculate using the results of the daily averages.
- 6) At the end of each averaging period, store the average values for the period on the hard disk for historical record-keeping and reset the present period average register to the present value of the variable.
- 7) The active database must include the present period average and previous period average for each variable and averaging period.
- j. Totals:
 - 1) Provide a program to calculate and store hourly, daily, and monthly totalization of analog variables.
 - 2) Assign a scaling factor to each variable to convert to the appropriate units based on a 1-minute totalizing interval.
 - 3) Assign a separate factor for each totalizing interval.
 - 4) Variables for which totalization is inappropriate must have scaling factors of zero.
 - 5) At the end of each totalizing period, store the totalized values for the period on the hard disk for historical record-keeping and reset the present period totalization register to zero.
 - 6) The active database must include the present period total and previous period total for each variable and totalizing period.
- k. Engineering units:
 - 1) Provide software to allow the system and the operator to convert all the measured analog variables to any desired engineering units.
 - 2) The operator must be able to view displays and generate reports of any measured variable in one or more engineering units such as flow in gpm, mgd, cfs, and acre-feet per day.
 - 3) Pre-program the conversion of the engineering units, and, if not pre-programmed, the operator must be able to program new engineering unit conversions by using simple methods, e.g., multiplication of the database attributes by a constant.
 - 4) The programming method must be at a level and compatible with the specified training of the operator and the Owner's personnel.
 - 5) New conversions must not require the services of a special programmer and/or special, high-level, programming training.
- l. Control modules:
 - 1) For each control function configured, whether processed at the RTU, PLC, or operator interface, maintain a file of necessary data including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.
 - 2) Input and output assignments, setpoints, and constants must be adjustable by the operator through the operator interface.
 - 3) Provide control algorithms for manual control with output values adjustable by the operator.
- m. Analog outputs:
 - 1) Analog outputs must be maintained as part of the database.
 - 2) These outputs must be adjustable manually by the operator through the operator interface or through automatic control algorithms.
18. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the

ICSC to optimize the location of the various functions between all software packages.

D. General control functions:

1. Analog control functions:
 - a. PID, lead/lag, signal select, alarm, limit, delay, and time base.
 - b. Furnish the control system complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR, and NXOR functions.
 - c. All math utilities must be linkable to process data points or manual inputs via control block configuration.
 - d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.
2. Discrete control functions:
 - a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays, and time base.
3. Software support:
 - a. Retain in firmware all control and logic functions at each RTU and PLC and in RAM at the operator interface.
 - b. Call each function as required by the configured controls to perform the intended function.
4. Control and status discrepancies:
 - a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status.
 - 1) For example, the system commands to start (call), and the pump fails to start (run status report back), within predetermined operator-programmable time delay (time disagree), then a discrepancy (fail) alarm shall be generated.
 - b. Involuntary change in the device's status must also generate an alarm:
 - 1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
 - c. Each command, status, and alarm must cause the color of the symbol to change.
 - d. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay period selected to be longer than the operating period of the control element:
 - 1) Delay periods for each final control element must be adjustable at the operator interface.
 - 2) List all time delays in the final documentation.
5. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

E. Control configuration:

1. Provide software to allow control strategies to be developed, and their operation initiated through the operator interface.

2. Provide standardized control point displays for defining the control functions including the function type, input/output addresses, setpoints, tuning constants, etc.
3. Provide a mechanism to link separate control functions together into an integrated control strategy.
4. Provide a mechanism to download operational/control setpoints developed at any operator interface to any PLC or RTU for operational implementation.
5. Provide a mechanism to define and implement operational/control setpoints locally at the PLC or RTU, and to upload them to the operator interface for operational record-keeping.
6. Perform control configurations on-line at the operator interface; the PLC or RTU may be taken off-line when being configured or downloaded.

F. Remote inputs and outputs (RIOs):

1. Platforms:
 - a. New: Modicon X80.
 - b. Retrofitted: Quantum.
2. Compatible with all of the PLCs being furnished under this Contract, shall be by the same manufacturer as the PLCs, and, as a minimum, include:
 - a. Power supply.
 - b. Rack.
 - c. Backplane.
 - d. Communications module.
 - e. I/O modules.
 - f. Enclosure.
3. Provide all cables and software needed for a complete and operational RIO system as specified in the Contract Documents.
4. Provide a group of pre-assigned diagnostic registers to report RIO system faults to the driver PLC.
5. The control system must continue operation should a fault occur on a single RIO drop:
 - a. Upon clearing the fault, restart communications to that drop automatically.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Utilize personnel to accomplish or supervise the physical installation of all elements, components, accessories, or assemblies:
 - 1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.
- C. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.
- D. General:
 - 1. The control system logic program shall reside at the PLC level.
- E. Use the tag and loop identifications found on the P&IDs for all tags used and/or assigned as part of the application software work provided by the ICSC.
- F. Program the PLC logic using the following language(s):
 - 1. Ladder Diagram.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

- A. Provide a minimum of 4 CD/DVD copies of the following:
 - 1. Application software:
 - a. Finalized fully annotated copy of programmed PLC logic in its native format.
 - b. Cross-referenced index of all PLC registers or points.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Tailor training specifically for this Project that reflects the entire control system installation and configuration.
- C. Perform training by pre-approved and qualified representatives of the ICSC and/or manufacturer of the PLC hardware and programming software:
 - 1. A representative of the ICSC may perform the PLC hardware training only if the representative has completed the manufacturer's training course for the PLC hardware.
 - 2. A representative of the ICSC may perform the PLC programming software training only if the representative has completed the manufacturer's training course for the PLC programming software.

3.11 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17733

CONTROL SYSTEMS: NETWORK MATERIALS AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Materials and equipment used in process control and LAN networks including:
 - a. Network switches.
 - b. Media converters.
 - c. Routers.
 - d. Patch panels and other data network hardware.
 - e. Related accessories.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 802.1X – Standard for Local and Metropolitan Area Networks—Port-Based Network Access Control.
 - 2. 802.3 - Standard for Ethernet.
 - 3. 802.3ab - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan Area Networks - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Physical Layer Parameters and Specifications for 1000 Mb/s Operation over 4 pair of Category 5 Balanced Copper Cabling, Type 1000BASE-T.
 - 4. 802.3u - Standards for Local and Metropolitan Area Networks: Supplement - Media Access Control (MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 100Mb/s Operation, Type 100BASE-T (Clauses 21-30).
 - 5. 802.11b - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher Speed Physical Layer (PHY) Extension in the 2.4 GHz band.
- C. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
 - 1. 568-C.3 - Optical Fiber Cabling Components Standard.
- D. Underwriters Laboratories, Inc. (UL).

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SYSTEM DESCRIPTION

- A. Provide all network equipment identified in the Contract Documents.

1.05 SUBMITTALS

- A. Furnish submittals as specified in the Contract Documents and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. Include information on all network equipment.
 - 2. Manufacturer's operation and installation instructions.
- C. Shop drawings:
 - 1. Complete set of drawings including but not limited to:
 - a. System block diagram showing relationship and connections between devices provided under this Contract and existing equipment. Include manufacturer and model information, and address settings.
 - b. Network riser diagram.
 - c. Network port diagram, which physically locates all ports within the facility, and identifies their patch panel and switch port.
 - d. Construction drawings for all equipment cabinets, including dimensions, identification of all components, preparation and finish data, and nameplates.
 - e. Electrical connection diagrams.
 - f. Complete grounding requirements.
 - 2. Furnish data sheets for each component together with a technical product brochure or bulletin:
 - a. Manufacturer's model number.
 - b. Project equipment tag.
 - 3. Complete and detailed bills of materials broken up by each cabinet. Each bill of material item will include the following:
 - a. Quantity.
 - b. Description.
 - c. Manufacturer.
 - d. Part numbers.
- D. Test reports:
 - 1. As specified in Section 17950 - Commissioning for Instrumentation and Controls and noted in this Section.
 - 2. Signed test results as described in this Section.
 - 3. Test results shall include:
 - a. Narrative describing the test procedures followed.
 - b. Block diagram of test set up.
 - c. Manufacturer's information on test equipment used.
 - d. Detailed test results.
 - e. A narrative summarizing the results of the testing and identifying any further action required.
- E. Operating manuals:
 - 1. Complete installation, operation, calibration, and testing manuals as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

- F. Record drawings:
 - 1. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 2. Electrical connection diagrams shall be revised to reflect any changes made in the field and submitted as record drawings.

1.06 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. Ethernet switches:
 - 1. Managed Enterprise Ethernet switches:
 - a. Manufacturers: One of the following no equal:
 - 1) Cisco, Catalyst 2960.

- b. Properties:
 - 1) Hardware:
 - a) 19-inch rack mountable modular switch.
 - b) Power supply:
 - (1) Provide redundant power supplies.
 - (2) 120 VAC, 60 hertz, 1 phase 1,600 watts; 6,000 watts if Cisco 6500 is chosen.
 - c) Console management port.
 - d) Open module slots for the addition of modules as described below.
 - 2) Performance:
 - a) Switching capacity: 18 Gbps, minimum.
 - b) Address table size: 8,000 entries, minimum.
 - c) Gigabit throughput.
 - 3) Environment:
 - a) Operating temperature range: 32 to 113 degrees Fahrenheit.
 - b) Humidity: 10 to 90 percent, non-condensing.
 - 4) Electrical:
 - a) Maximum power consumption: 270.1 watts; 2,900 watts if Cisco 6500 is chosen.
 - 5) Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes but not limited to:
 - a) Port Monitoring.
 - b) Remote switch management.
 - c) Port Security.
 - d) Rapid Spanning Tree protocol.
 - 6) Connector type:
 - a) Fiber: SC, LC, or MTRJ. Provide necessary conversion patch cables as per requirement that have minimum power loss.
 - b) Copper: RJ-45.
 - 7) Modules:
 - a) 10/100/1000-Base-T:
 - (1) Protocol: IEEE 802.3 Type 10Base-T; IEEE 802.3u Type 100Base-TX; 802.3ab Type 1000Base-T.
 - (2) Auto-sensing.
 - (3) 208 ports per module.
 - b) Provide modules required to provide network connections as required:
 - (1) As required to provide the number of connections required plus 20 percent spare ports of each type used.
 - c) GBIC or Transceiver module:
 - (1) If required, provide transceiver module to interface with single-port transceivers as required.
 - 8) Spare parts:
 - a) Provide the following spare components:
 - (1) One spare module of each type provided.
 - (2) One spare Ethernet switch backplane.
2. Managed Process Rack Mount Ethernet switches:
 - a. Manufacturers: The following, no equal:
 - 1) Moxa, 500 Series.
 - b. Properties:

- 1) Hardware:
 - a) Power supply:
 - (1) Provide redundant power supplies.
 - (2) 24 VDC, 1,100 watts per power supply.
 - 2) Performance:
 - a) Switching capacity: 88 Gbps
 - b) Gigabit throughput.
 - c) 10/100/1000Base-T RJ-45 Copper Ports (quantity as required).
 - d) Ports will auto negotiate speed duplex and MDIX.
 - e) Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes but not limited to:
 - (1) SNMP
 - (2) VLAN.
 - (3) QoS.
 - f) IGMP Snooping with Ethernet I/P plug and play compatibility.
 - g) 802.1d, 802.1w, 802.1D RSTP.
 - h) Rapid Spanning Tree protocol.
 - 3) Environment:
 - a) Operating temperature range: 32 to 113 degrees Fahrenheit.
 - b) Humidity: 5 to 95 percent, non-condensing.
 - c) Elevation: Up to 10,000 feet.
 - 4) Electrical:
 - a) Maximum power consumption: 291 watts.
 - 5) Connector type:
 - a) Copper: RJ-45.
 - 6) Mounting:
 - a) DIN Rail mounting.
3. Managed Ethernet switches:
- a. Manufacturers: The following, no equal:
 - 1) Moxa, 300 Series.
 - b. Properties:
 - 1) Hardware:
 - a) 10/100BASE-FX.
 - b) 100BASE-FX.
 - c) Power supply:
 - (1) Provide redundant power supplies.
 - (2) 24 VDC, 200 watts/per power supply.
 - (3) Store and forward.
 - d) No fans or moving parts.
 - 2) Performance:
 - a) Full/half-Duplex.
 - b) MDI/MDI-X Auto-sensing.
 - 3) Environment:
 - a) Operating temperature range: 32 to 140 Degrees Fahrenheit.
 - b) Humidity: 5 to 95 percent, non-condensing.
 - 4) The Ethernet switch shall be capable of performing basic switching without special programming or configurations.
 - 5) Ports:

- a) As required to provide the number of connections required plus 10 percent spare of each type used.
- 6) Connector type:
 - a) Fiber: SC.
 - b) Copper: RJ-45.
- 7) Mounting:
 - a) Din Rail.

B. Routers:

- 1. Manufacturers: The following or equal:
 - a. Cisco, 2900 series.
- 2. Properties:
 - a. USB Port.
 - b. Compact Flash Port.
 - c. 128 MB RAM.
 - d. Hardware:
 - 1) 19-inch rack mountable.
 - 2) Power supply:
 - a) Provide redundant power supplies:
 - (1) 120 VAC, 60 hertz, 1 phase 280 watts.
 - b) Ethernet ports 10/100 TX: 2.
 - e. Environment:
 - 1) Operating temperature range: 32 to 95 degrees Fahrenheit.
 - 2) Humidity: 15 to 70 percent, non-condensing.
 - f. Capable of performing basic filtering and networking with web based graphical user interface:
 - 1) VPN Support.
 - 2) IP Phone Support.
 - 3) Email Support for 100 mailboxes.
 - g. Interface card slots:
 - 1) Slots total: 4:
 - a) Slots support for HWIC, WIC, VIC and VWIC: 2.
 - b) Slots support for WIC, VIC and VWIC: 1.
 - c) Slots support for VIC and VWIC: 1.
 - h. Connector type:
 - 1) Copper: RJ-45.
 - i. Mounting:
 - 1) Provide hardware for 19-inch rack mounting hardware.

C. Media converters:

- 1. Copper to fiber transceiver:
 - a. Manufacturers: One of the following or equal:
 - 1) Moxa.
 - 2) N-Tron.
 - b. Transceiver shall be used to convert from Half/Full Duplex Ethernet to multimode fiber Ethernet 100BASE-FX:
 - 1) Meets requirements of IEEE 802.3 Ethernet standard.
 - 2) Supports Half/Full Duplex.
 - 3) Connector type:
 - a) Fiber: SC.
 - b) Copper: RJ-45.
 - 4) Power supply:

- a) 110 VAC, 60 hertz.
 - b) 24 VDC, 6 watts.
 - 5) Mounting:
 - a) Provide mounting hardware.
 - b) DIN rail mounting.
- D. Patch panels:
 - 1. General:
 - a. Fiber:
 - 1) All optical fibers shall be provided with strain relief and terminated at a fiber patch panel. Final connections between the patch panel and the fiber optic network equipment shall be made via fiber optic patch cords.
 - 2) All fibers, active and dark, shall be terminated at the patch panels.
 - 3) Interconnect and patch panel housings shall provide space for excess fiber and provide strain relief for the fiber cable.
 - 4) Fiber cables shall be installed such that the outer sheath of the cable is carried into the interconnect enclosure or patch panels before breaking out buffer tubes.
 - b. Copper:
 - 1) Final connections between the patch panel and network equipment shall be by patch cords.
 - 2) All premises cables shall be terminated at the patch panels.
 - 3) Cables shall be installed such that the outer sheath of the cable is carried into the interconnect enclosure or patch panels before breaking out conductors.
 - 4) Maintain twist of broken out conductors per EIA/TIA standards.
 - 2. Rack mounted Copper Patch panels:
 - a. Manufacturers: One of the following or equal:
 - 1) Ortronics.
 - 2) Panduit.
 - b. Copper patch panels and connectors shall meet the following (minimum) requirements:
 - 1) Category 6.
 - 2) RJ-45 patch cord termination:
 - a) Punch Down Block.
 - b) Performance tested modular jack, capable of being re-terminated up to 20 times.
 - 3) Mounting: 19-inch rack mount.
 - 4) UL listed and UL-C certified.
 - 5) Support network line speeds in excess of 1 and 10 gigabit per second and be backward compatible with Category 5e cables.
 - 6) Accessories:
 - a) Removable rear cable management bracket.
 - b) Rear individual port labels.
 - c) Front color coded individual port labels.
 - c. Provide copper patch cables as required to support all network devices.
 - d. Provide 4 spare straight through patch cables.
 - e. Provide 1 spare cross over cable.
 - 3. Rack mounted fiber patch panels:
 - a. Manufacturers: One of the following or equal:
 - 1) Panduit.

- 2) Corning cable systems.
- 3) Ortronics.
- b. Fiber patch panels shall meet the following (minimum) requirements:
 - 1) Use for combination of splicing and termination of fiber-optic building cable or outside plant cables.
 - 2) 1RU and 2RU height fully enclosed shelves.
 - 3) Slide-out, tilt-down tray.
 - 4) Interchangeable modules.
 - 5) Accessories:
 - a) Hinged front doors.
 - b) Front cable management trough.
 - c) Top cover panel.
- c. Modules for modular shelves shall meet the following (minimum) requirements:
 - 1) Interchangeable modules available in LC for multimode and single mode solutions.
 - 2) Adapters color coded per TIA/EIA 568C.3
- 4. Cabinet style fiber patch panels:
 - a. Wall mounted interconnect:
 - 1) Use for the termination of a single cable outside of cabinets, in small enclosures or as indicated on the plans.
 - 2) Wall mounted fiber interconnects shall be provided as complete units including the housing, the connector panels and the fiber connectors.
 - 3) Wall mounted fiber interconnects shall provide physical protection for both the incoming cable and the outgoing patch cords.
 - 4) Capacity:
 - a) As shown on the plans, minimum 6 connections.
 - 5) Accessories:
 - a) Door lock.
 - b) Blanks for unused connector panels.
 - 6) Manufacturers: The following or equal:
 - a) Corning Cable Systems, Wall-Mountable Interconnect Center.
 - b. DIN rail mounted:
 - 1) Use for the termination of a single cable inside of cabinets, in small enclosures or as indicated on the plans.
 - 2) DIN rail mounted cable interconnects shall be provided as complete units including the housing, the connector panels and the fiber connectors.
 - 3) DIN rail mounted cable interconnects shall provide physical protection for both the incoming cable and the outgoing patch cords.
 - 4) Capacity:
 - a) As shown on the plans, minimum 6 connections.
 - 5) Accessories:
 - a) Blanks for unused connector panels.
 - 6) Manufacturers: One of the following or equal:
 - a) Hirschmann, MIPP.
 - b) DINSpace, SNAP XL.
- E. Network racks:
 - 1. Post open rack: 2:
 - a. Manufacturers: One of the following or equal:
 - 1) Hoffman DataCom.

- 2) Panduit.
 - 3) Dell.
 - b. Properties:
 - 1) 19-inch rack mount.
 - 2) Side rail cable management.
 - 3) Constructed of 10 grams steel.
 - 4) Provided vented shelf.
 - 5) Velcro cable wraps.
 - 6) 20 Amp surge protected power strip.
 - 7) Seismic rated.
- 2. Server cabinets:
 - a. Manufacturers: The following or equal:
 - 1) Hoffman Proline.
 - 2) Panduit.
 - 3) Dell.
 - b. Properties:
 - 1) Glass front door (lockable).
 - 2) Perforated rear door (lockable).
 - 3) Perforated top with 2 cable entries.
 - 4) Fully welded frame.
 - 5) 20 Amp surge protected power strip.
 - 6) Velcro cable wraps.
- 3. Networking closed 4-post cabinets:
 - a. Manufacturers: One of the following or equal:
 - 1) Hoffman.
 - 2) Panduit.
 - 3) Dell.
 - b. Properties:
 - 1) Integral keyboard and mouse drawer.
 - 2) CPU cabinet with locking front door.
 - 3) CRT cabinet with locking front door.
 - 4) Louvered rear door.
 - 5) Power strip.
 - 6) Corded fan kit.
 - 7) Furnish shelves as needed.
 - 8) Furnish writing surface.
 - 9) Furnish cable keeper/organizer.
 - 10) NEMA 1.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Provide duplex patch cords to connect the interface cards provided with the associated patch panels.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide installation and configuration for the new and existing managed Ethernet switches. Provide configuration of the Ethernet switch network for a complete, functioning plant control system:
 - 1. Refer to SCADA block diagrams for all new network connections.
 - 2. Provide configuration for all managed Ethernet switches and other components including but not limited to VLAN (virtual local area network), additional Plant PLC communication cards and separate managed Ethernet switches as required, such that there is isolation of the following networks:
 - a. Field and PLC I/O network: This includes the connections between the Plant PLC and:
 - 1) Plant PLC expansion racks.
 - 2) Plant PLC remote I/O (RIO) racks.
 - 3) Field Networks.
 - 4) HMI(s) part of a Plant PLC.
 - 5) Vendor furnished Ethernet network components.
 - b. Valve Actuator network: This includes the connections between the Plant PLC and the valve master stations.
 - c. Process Control network: This includes the connections between the Plant PLC and other Plant PLCs.
 - d. SCADA network: This includes the connections between the various SCADA equipment including but not limited to servers (existing), workstations and printers.
 - e. Security network: This includes any security hardware with Ethernet communication as provided by the security/telephone/internet sub-contractor.
 - 3. The process floor managed Ethernet switches for the process control network shall be configured and programmed for rapid fail over protection.
 - 4. The enterprise level managed Ethernet switches shall be configured for a communication protocol that is compatible with the process control network's rapid fail over protocol.
- C. All racks shall be level and plumb.
- D. Install Velcro wrap on all cable bundles within the network rack/enclosure.
- E. All cables and equipment shall be installed in strict conformance with the manufacturer's recommendations:

1. Cables shall be installed avoiding sharp bends.
 2. Install cable using lubricant designed for cable pulling.
 3. Cable ties or other cable supports shall be installed without crimping the LAN cables.
 4. Install LAN cables without splices.
 5. Installed bend radii shall not exceed 4 times the cable diameter.
 6. Terminated all pairs at the jack and the patch panel.
- F. Install cables a minimum of 40 inches away from electrical motors and transformers.
- G. Install cables a minimum of 12 inches away from fluorescent lighting.
- H. Individual pairs will be untwisted less than 1/2-inch at termination points.
- I. All cables and terminations shall be labeled with cable designations as specified in Section 16075 - Identification for Electrical Systems.
- J. Each data port shall be individually labeled with its patch panel/switch port ID:
1. Labeling must be printed - no handwritten labels will be allowed.
- K. At the completion of the wiring installation, provide the following documentation:
1. A plan-view of the premise(s) showing the jack numbering scheme.
 2. A printed certification report for the entire wiring installation showing compliance with all EIA/TIA specifications for data cable.
 3. Reports such as those generated by Fluke DSP cable certification equipment meet this requirement.
 4. Each device with a unique IP address shall be individually labeled with its IP address. The labeling must be printed; handwritten labels will not be allowed.
- L. Managed Ethernet switches:
1. Configure switches to prevent broadcast storms.
 2. Utilize IGMP Snooping on all network switches.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING

- A. Perform all firmware installations, configuration and other set up, as required, to place the network into proper operation.

3.09 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. After completion of the cable system tests and before placing the system in operation, power up all devices installed on the LAN and verify communication between the devices.
- C. Verify that all equipment is operable on the network simultaneously. Confirm that all network device communications settings are properly configured.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17950

COMMISSIONING FOR INSTRUMENTATION AND CONTROLS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Testing requirements that apply to process control and instrumentation systems for the entire Project.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Electronics Industries Alliance (EIA).
- C. Telecommunications Industry Association (TIA).

1.03 DEFINITIONS

- A. As specified in the Contract Documents and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
 - 1. Complete End-to-End Testing (CEET) - Signals are tested from the field device through the PLC program, the network, and all the way to the operator's HMI graphic screens.
 - 2. Loop Validation Tests - Signals are tested from the field device to the PLC.
 - 3. Platform Testing: Testing of the PLC and SCADA/HMI at the manufacturer's or programmer's shop to demonstrate the program's functionality based upon specified and designed control requirements.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

- A. Furnish submittals as specified in the Contract Documents.
- B. General:
 - 1. Reference additional detailed test submittal scheduling and prerequisite requirements as specified in the Sequencing article of Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- C. Overall test plan:

1. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.
 2. Develop and submit an overall testing plan for the PCIS. The overall test plan to be reviewed and approved by the Engineer before detailed test plans, procedures, and forms will be reviewed.
 3. Describe the test phases as they apply specifically to this Project and each process system.
 4. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
 5. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
 6. Provide examples of proposed forms and checklists.
- D. Test procedures:
1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
 2. Provide a statement of test objectives for each test.
 3. Prepare specific procedures for each process system.
 4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
 5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
 6. Describe the expected role of the Engineer, as well as any requirements for assistance from Owner's staff.
 7. Provide the forms and checklists to be used.
- E. Test forms:
1. Submit completed calibration forms, test forms, and checklists.
 - a. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
 - b. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
 - c. Sample test forms at the end of this Section show the minimum required content.
 - 1) The sample test forms have not been customized for this Project.
 - 2) Contractor shall develop and submit test forms customized for the Project and meeting the specified test and submittal requirements.
- F. FAT procedure additional minimal requirements:
1. Prepare and submit a FAT procedure which includes:
 - a. Control system testing block diagram.
 - b. Estimated test duration.

- G. Details on the simulator construction, components, and operation. Testing binders:
 - 1. Sub-system to be tested, provide and submit a test binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
 - 2. Fill out in advance headings and all other information known before the test.
 - 3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
 - 4. Include or list reference material and provide separately at the time of the test.
 - 5. Record test results and verify that all test requirements and conditions have been met.
- H. Test reports:
 - 1. At the conclusion of each test, submit a complete test report, including all test results and certifications.
 - 2. Include all completed test binders, forms, and checklists.
 - 3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

1.06 QUALITY ASSURANCE

- A. Test personnel:
 - 1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this Project and the equipment, software, and systems before being assigned to the test program.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Installation supervision:
 - 1. Provide as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. Commissioning as specified in the Contract Documents.
- B. Testing and training phase:
 - 1. Source testing:
 - a. Manufacturer services: Provide as specified in the table below.

System	Source Testing (Witnessed or Non-Witnessed)
Packaged Control System	Witnessed
Control Strategies	Witnessed
Specific Control Strategies	Witnessed
Control Systems - Panels, Enclosures, and Panel Components	Witnessed
Commissioning for Instrumentation and Controls	Witnessed

- b. Prerequisite requirements:
 - 1) Engineer approval of the hardware and equipment source testing submittal, Manufacturer Certificate of Source Testing, is required before proceeding to Preliminary FAT.
 - c. Preliminary FAT (Pre-FAT):
 - 1) The purpose of the Pre-FAT is to provide assurance that the HMI/SCADA system is ready for the full, witnessed FAT, in terms of both stability and functionality.
 - a) Debugging of software and troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT.
 - b) Contractor shall fully test the HMI/SCADA system and fix all deficiencies found before the FAT.
 - 2) Conduct utilizing test procedures approved by Engineer

- 3) Owner shall have the right to witness any or all of the Pre-FAT testing and shall be notified in writing 20 days before the start of the pre-FAT.
 - 4) Submit a letter, signed by the Contractor's project manager or company officer, certifying that integrated system hardware and software has been tested and confirmed to be fully operational and in compliance with the requirements specified in the Contract Documents and is fully ready for the full, witnessed FAT.
 - a) Attach the completed pre-FAT test forms, signed by the Contractor's staff.
 - 5) Engineer approval of the pre-FAT submittal is required before proceeding to FAT.
- d. FAT hardware and communications testing:
- 1) Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements specified in the Contract Documents.
 - 2) The complete PCIS system including operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other HMI/SCADA equipment, shall be assembled, connected, and software loaded for a fully functional FAT of the integrated system.
 - 3) Testing simulation:
 - a) Inputs and outputs shall be simulated and proper control and system operation shall be validated.
 - b) FAT shall make use of simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the HMI/SCADA system.
 - (1) The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
 - (2) The simulator may consist of a PLC, operating under a HMI/SCADA software package, or other approved software that has its I/O points wired to PLC's I/O points.
 - (3) Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.
 - 4) Additional source tests are specified in other sections of the Instrumentation and Control Specifications.
 - 5) Owner shall have the right to witness any or all of the FAT testing and shall be notified in writing 20 days before the start of the FAT.
 - 6) Verify communications between the hardware and the programmer's software comply with specified requirements.
 - a) For systems that contain RTUs or remote communications with other devices, the complete communications system must be factory tested, including actual interfacing with telephone company equipment and/or the actual radios used for radio based telemetry systems.
 - 7) Panel inspections:
 - a) Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the accepted shop drawings.

- (1) Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
- b) Inspection forms:
 - (1) Provide panel inspection forms as part of the FAT procedures submittal.
 - (2) A sample FAT control panel form has been provided at the end of this Section.
- 8) I/O test:
 - a) Engineer will verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices.
 - b) Test methodology:
 - (1) Discrete inputs:
 - (a) Apply appropriate input from simulator at panel terminal, observe input card indicator, observe data value at each indicated data address, and observe data received at field wiring terminals or operator interface screen.
 - (2) Discrete outputs:
 - (a) Issue commands from operator interface screen or PLC, verify output card indicator light, and measure response at field wiring terminals or multimeter.
 - (3) Analog inputs:
 - (a) Apply appropriate analog input signal at panel terminals on simulator, observe data value at each indicated data address, and observe data properly received at field wiring terminals or operator interface screen.
 - (b) Check each point at 0 percent, 50 percent, and 100 percent of scale.
 - (4) Analog outputs:
 - (a) Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at field wiring terminals or multimeter.
 - c) Test forms to include, but not be limited to the following data:
 - (1) PLC and panel number.
 - (2) I/O type.
 - (3) I/O tag name.
 - (4) Rack/slot/number of I/O point.
 - (5) Check-off for correct response for each I/O point.
 - (6) Comments field.
 - (7) Initials of individual performing test.
 - (8) Date test was performed.
 - (9) Witness signature lines.
- 9) System configuration test:
 - a) Demonstrate and test the setup and configuration of operator stations, servers, development stations, and peripherals.

- b) Demonstrate utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
 - c) Demonstrate the proper operation of peripheral hardware.
 - d) Demonstrate general HMI/SCADA functions.
 - e) Demonstrate proper operation of log-on and other security access functions.
 - f) Demonstrate the proper operation of all historical data storage, trend, display, backup, and report functions.
 - g) Test automatic fail over of redundant equipment.
 - h) Demonstrate the proper operation of the alarm display and acknowledgement functions.
 - i) Test forms:
 - (1) For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.
 - (2) List the specific tests and steps to be conducted.
 - (3) For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
 - (a) Include signature and date lines.
- 10) Engineer approval of the FAT Communication Testing activities is required before proceeding to FAT Platform Testing.
- e. FAT Platform Testing - Control logic test:
 - 1) Verify the PLC, HMI and SCADA, provides monitoring and control functionality based upon specified and designed control requirements.
 - 2) Testing requirements:
 - a) Demonstrate each function described in the Control Strategies.
 - b) Demonstrate in detail how each function operates under a variety of operating scenarios.
 - (1) Test to verify the application of each general control strategy function to each specific control strategy or loop description.
 - c) Demonstrate the proper operation of the programming and configuration for each control strategy or loop description.
 - (1) Test each strategy or loop description on a sentence by sentence and function by function basis.
 - (2) Loops with similar or identical logic must each be tested individually.
 - (3) Test the boundaries of each numeric operator input by entering values outside of the allowable range.
 - d) Demonstrate the proper operation of all digital communication links and networks.
 - (1) Verify each digital communication I/O point.
 - e) Failure testing: Demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to: equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to HMI and/or SCADA hardware), process equipment failure, and high system loading conditions.

- 3) Test forms:
 - a) Submit completed test forms for each loop including but not limited to the fully revised and approved control strategy.
 - b) Identify the cause and effect as each I/O point is toggled through the simulator.
 - (1) Identify and track proper and/or improper operation of the loop.
 - c) Note any deficiencies or operational changes on the forms for correction and documentation:
 - (1) Include signature and date lines.
 - 4) Engineer approval of the FAT submittal is required prior to shipment of system components.
2. Owner training:
 - a. Demonstration requirements are specified in this Section.

Table 1			
Course Title	Minimum Course Length (hours per session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
System Overview			
Operator Training - Basic			
Operator Training - Advanced			
CIS (Computer) Equipment Maintenance			
HMI Software			
Historian System Training			
Reports Training			
PLC Hardware			
PLC Software			
LOI Hardware and Software			
Network Equipment			
Follow-Up Training			
Instrument Training			
Analytical Instrument Training			

3. Training course requirements:
 - a. System overview training:
 - 1) Furnish training courses that give the Owner's supervisory level personnel and overview of all elements of the PCIS system that focus on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.
 - 2) Furnish a training course that gives the Owner's supervisory level personnel and overview of the new Contractor-provided elements of

the PCIS system. Focus on the overall functional aspects of each new elements of the control system, particularly the mechanical system vendor-provided control packages.

- b. Operator training:
 - 1) Furnish training courses that instruct system operators in the efficient operation of all aspects of the PCIS that include not only the general operation of the control system but also the operation of specific system features.
 - 2) Furnish training courses that instruct system operators in the efficient operation of Contractor-provided aspects of the PCIS that include not only the general operation of each control system but also the operation of specific system features.
 - 3) Operator's training shall include the following for each vendor package and programmable device:
 - a) Control system overview: Architecture, equipment functions, software components, etc.
 - b) Display navigation, overview, and types of displays.
 - c) Process and equipment monitoring and control: Basic principles and operation.
 - d) Logging ON and OFF the system and description of the security and access system.
 - e) Alarm subsystem.
 - f) Trending: Provide a thorough session on how to use all trending functions.
 - g) Reports: How to access, print, and review content.
 - h) Control strategies: Present an average 15-minute review of each control strategy, including a hands-on demonstration of screens and operator functions for each.
 - i) Instruction on the use of all operational functionality alarm logging, trending, displays, database, reports, and control software developed for the Project and incorporated in the installed PCIS system.
- c. PCS computer equipment maintenance training:
 - 1) Furnish training courses that will enable maintenance technicians to perform troubleshooting and repair of all system computer equipment. Include the theory of operation of the system as a whole, including related operating system and utility software.
- d. HMI software training:
 - 1) Furnish training courses that will enable the Owner's staff to develop and maintain all aspects of the operator interface system applications.
 - 2) Include topics:
 - a) Operating systems and utilities such as virus protection software.
 - b) Point (tag) database development and modification.
 - c) Graphic screen creation and editing.
 - d) Scripting.
 - e) I/O servers, drivers, etc.
 - f) PLC interface functions and software.
 - g) Displays, scripts conventions, and documentation.
 - h) Trending.
 - i) Alarms and events.

- j) System security, access levels, and areas of responsibility.
 - k) General system maintenance, including backups, history data archive, version control, file naming and cataloging conventions, and system file housekeeping.
- 3) Address not only the procedures associated with the control system's standard software packages, but in addition include material explaining the specific conventions used in developing the Project's system applications (graphics, PLC/RTU interface, scripts, control strategies, trends, etc.). In addition, provide instruction in the use of techniques for developing and maintaining current, comprehensive documentation for all installed system applications.
- e. Historian system training:
 - 1) Furnish the following training:
 - a) Introduction to relational databases.
 - b) Introductory training on the specific relational database program used for the historian server.
 - c) How to set up points for historian logging.
 - d) How to develop, edit, and print custom reports, in detail.
 - e) Introduction to use of the query language.
 - f) System maintenance.
 - g) Interface to networks outside of the control system.
- f. Report training:
 - 1) Furnish training courses that will enable the Owner's staff to develop and maintain all aspects of reports.
 - 2) Include topics:
 - a) Generation of a developed report.
 - b) Generation of a new report.
 - c) Modification and editing of reports.
 - d) Formatting reports.
 - e) Manual entry and automatic entry of data from a database.
- g. PLC hardware training:
 - 1) Furnish training on PLC hardware and on related components, including battery backup equipment, UPSs, LOI hardware, control circuits, and analog circuits.
 - 2) Furnish training on PLC hardware principles, product features, proper installation, operation, troubleshooting, and maintenance.
 - 3) PLC training may be provided by manufacturer's certified trainers.
- h. PLC software training:
 - 1) Furnish training on PLC software.
 - 2) 2 types of training are required, basic and project-specific:
 - a) Basic PLC software training covers the principles of PLC programming and the specific features and function of the PLC products used on this Project, provided by one of the PLC manufacturer's certified trainers.
 - b) Project-specific PLC software training covers the programming conventions, new standardized software modules, specific control strategy programs, and documentation created for the Work performed under this Contract. This training includes the specific knowledge needed to modify, expand, duplicate, troubleshoot, and repair the PLC programs provided under this Contract, provided by a qualified [member of the ICSC][individual] who is thoroughly familiar with the delivered

system, and is one of the senior programmers who programmed the PLCs for this Project.

- i. LOI hardware and software training:
 - 1) Provide the following:
 - a) Overview of hardware and firmware, including starting, stopping, and PLC interface.
 - b) Configuration of tag database.
 - c) Creating, editing, and saving display screens.
 - d) Troubleshooting.
- j. Network equipment training:
 - 1) Furnish basic training on all network hardware, switch and router configuration and software, and network monitoring software.
 - 2) Include a detailed description and explanation of the installed network architecture, media, and functions.
 - 3) Furnish an overview of the function and operation of each piece of network equipment.
 - 4) Furnish training on network maintenance troubleshooting and repair.
 - 5) Furnish training on how to install spare or off-line backup equipment.
 - 6) Basic network overview:
 - a) Discuss a basic network overview for each site.
 - b) Discuss the architecture (loop, star, etc.), media redundancy, and items that are not readily apparent to staff.
 - c) Discuss how to monitor the network health through the HMI network screen.
 - d) Discuss both enterprise level networks, the PCS communications network, and the field network.
 - 7) Ethernet switches:
 - a) Discuss the various types of switches (Layer 2, Layer 3, etc.).
 - b) Discuss switch health monitoring through the HMI.
 - c) Discuss the VLAN configuration (what ports should be used for what network, etc.).
 - d) Discuss testing procedures.
 - 8) Field networks:
 - a) General:
 - (1) Discuss general principles behind likely device failures and actions to take to resolve such failures for each type of field network.
 - b) Modbus networks:
 - (1) Discuss Modbus TCP/IP and Modbus RTU converters for the SKF.
 - 9) Wireless networks:
 - a) Discuss parameters specific to wireless networks including, but not limited to: remote resetting options, bandwidth availability, channel speed, and ultimate channel capacity.
- k. Follow-up training:
 - 1) Provide a series of on-site follow-up training classes beginning after process start-up of the SCADA/PCIS system. The intent for these classes is to provide the Owner's personnel the opportunity for a review and "refresher" of the training topics and material after they have had some experience using the system.
 - 2) Mutually schedule and develop the content of these classes with the Owner no later than 1 month before the beginning of the first session:

- a) Schedule at the Owner's discretion on non-consecutive days spaced out over the process start-up and warranty period.
 - l. Instrumentation training:
 - 1) Furnish training covering all instruments and control panels.
 - 2) Furnish the specified quantity of training, allocated to cover new instruments and hardwired controls as specified in this Section and specifically determined in the accepted training plan.
 - 3) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the instruments furnished within this Project.
 - 4) Furnish training on the operation of new hardwired controls.
 - m. Analytical instrument training:
 - 1) Furnish training covering all analytical instruments.
 - 2) Furnish the specified quantity of training, allocated to cover new analytical instruments as specified in this Section and specifically determined in the accepted training plan.
 - 3) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the analytical instruments furnished within this Project.
 - 4) Provide training by manufacturer.
- 4. Recording training sessions:
 - a. Record all training.
 - b. Produce audio-visual presentations by recording the actual training sessions of the Owner's personnel.
 - c. Furnish digital video disk (DVD) format.
 - d. These disks become the property of the Owner and cover, in detail, the training for the specific hardware and software of all the systems provided for the Project.
 - e. Provide all the necessary cameras and recording equipment.
- 5. Installation testing:
 - a. Calibration:
 - 1) Performed by Contractor and ICSC.
 - 2) Calibrate and adjust all instruments, devices, valves, and systems, in conformance with the component manufacturer's instructions and as specified in these Contract Documents.
 - 3) Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
 - a) Calibration for discrete devices:
 - (1) Calibrate and adjust devices for reliable operation and to avoid nuisance tripping.
 - b) Calibration for ultrasonic and radar level devices:
 - (1) Provide Echo Transmission and signal quality on level transmitters including guided and unguided units.
 - (a) Submit printout of the actual transmission and parameters.
 - (2) Adjust mounting, as required, to obtain accurate readings.
 - (3) Post mounting: Provide any additional calibration required by manufacturer.
 - c) Calibrating analog transmitters:
 - (1) Components having adjustable features are to be set accurately for the specific conditions and applications of this installation.

- (2) Test and verify that components and/or systems are within the specified limits of accuracy.
 - (3) Calibration points:
 - (a) Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to NIST.
 - (4) Field verify calibration of instruments including units that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
 - d) Analyzer calibration:
 - (1) Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.
 - (2) Submit completed instrument calibration sheets for every field instrument and analyzer.
 - (3) Calibration tags:
 - (a) Attach a calibration and testing tag to each instrument, piece of equipment, or system.
 - (b) Sign the tag when calibration is complete.
 - e) Calibration for industrial networking test equipment:
 - f) Submit calibration documentation.
- b. Loop check:
 - 1) Performed by the Contractor.
 - 2) Cabling installed, terminated, and labeled.
 - 3) Perform continuity check of wiring to each field device through intermediate devices to field terminals in the cabinet.
 - 4) Complete loop check form for each device.
 - 5) Submit loop check test results before proceeding to the next step.
- c. Loop validation tests:
 - 1) Performed by the Contractor, ICSC, and manufacturer's representative, working together, and witnessed by the Owner or Owner's representative.
 - 2) Perform tests on the signal from each field device through intermediate devices to the I/O module on the PLC.
 - a) The PLC may or may not be connected to the network.
 - 3) Engineer approval of the loop validation test submittal is required before proceeding to CEET.
- d. LAN cable post-testing:
 - 1) Performed by Contractor and ICSC.
 - 2) After installing the cable and connectors, test all cables using the LAN certification to confirm the installation meets the requirements of the specification.
 - 3) Provide test documentation that includes the cable number, total length of cable, a permanent hard copy, as well as a-USB or CD copy of all traces.
 - a) After installing connectors:
 - b) Perform cable end-to-end testing on all installed cables from both ends of the cable. Test shall include cable system performance tests and confirm the absence of wiring errors.
 - c) Submit a signed test report presenting the results of the cable testing.

- d) Repair or replace any portions of the system not meeting TIA/EIA standards for installed cabling. Repaired sections shall be retested.
 - 4) Submit final documentation (including traces), using the approved test form, to the Engineer upon successful completion of the testing.
 - 5) Engineer approval of the LAN cable post-testing submittal is required before proceeding to CEET.
- e. Complete End-to-End Testing (CEET):
- 1) Performed by Contractor, ICSC, and manufacturer's representative working together, with assistance from the OWNER or the inspection staff, as needed.
 - a) The participants need to be dedicated full-time to CEET.
 - b) ICSC will provide staff to verify input signals at, and create output signals from, an HMI or Engineering Workstation.
 - c) Contractor and ICSC will be responsible for creating field signals and verifying proper operation of final control elements.
 - 2) Prerequisites:
 - a) CEET cannot begin until the successful completion of the preceding tests:
 - (1) Calibration.
 - (2) Loop check.
 - (3) Loop validation tests.
 - (4) LAN cable post-testing.
 - (5) Industrial network testing.
 - 3) Testing description:
 - a) This testing is to ensure all I/O signals operate to the intent of the design from the field device to the HMI and all other auxiliary controls and indicators in the PCS.
 - b) Connect PLC to the network to test signals from the field device through the PLC program, the network, and to the operator's HMI graphic screens. The outputs will be energized for a duration long enough to verify proper operation of the final control element.
 - c) SCADA screens:
 - (1) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
 - (2) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
 - (3) Retest any loop following any necessary corrections.
 - 4) Check control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the HMI/SCADA system.
 - a) Use actual process inputs wherever available.
 - b) Issue commands from the HMI/SCADA system and verify proper responses of field devices.
 - (1) Test SCADA system inputs from field device to SCADA system operator workstations.

- (a) Track responses through trend charts in the HMI/SCADA system.
 - (2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.
- 5) Discrete device testing:
 - a) Exercise each field device providing a discrete input to the HMI/SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
 - (1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
 - (2) Exercise starters, relay contacts, switch contacts, and observe proper operation.
 - (3) Calibrate and test instruments supplying discrete inputs, and observe proper operation.
 - b) Test each device accepting a discrete output signal from the HMI/SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
 - (1) Stroke valves through outputs from the HMI/SCADA system, and confirm proper directional operation. Confirm travel limits and any feedback signals to the HMI/SCADA system.
 - (2) Exercise motors starters from the HMI/SCADA system and verify proper operation through direct field observation.
 - (3) Exercise solenoids and other field devices from the HMI/SCADA system and verify proper operation through direct field observation.
- 6) Analog device testing:
 - a) Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
 - b) Apply provisional settings on controllers and alarm setpoints.
- 7) Analog input:
 - a) Exercise each field device monitoring the analog signal, through the HMI/SCADA system.
 - (1) Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements, and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
- 8) Analog output:
 - a) Exercise each field device requiring an analog command signal, through the HMI/SCADA system.
 - (1) Vary the output from the PLC HMI/SCADA system and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal.
 - (2) Manually set the output from the HMI/SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
- 9) Submit completed test forms.

- a) Discrete instrument input devices:
 - (1) Switch setting, contact action, and dead band.
 - (2) Valve position switches:
 - (a) Response in the PLC as the valve is stroked from the PLC.
 - (b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
 - (3) Operator interface switches (control stations and other pilot devices) and associated response.
 - (4) Starter and drive auxiliary device contact response.
 - (5) Response of all other discrete inputs to the PLC.
 - (6) Test equipment used and associated serial numbers.
 - b) Discrete output devices:
 - (1) Observed response of field device to the discrete output from the PLC.
 - (2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.
 - (3) Test equipment used and associated serial numbers.
 - c) Analog input devices:
 - (1) Calibration range.
 - (2) Calibration data: Input, output, and error at each test value.
 - (3) Analog input associated PLC register address.
 - (4) Value in PLC register at each test point.
 - (5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
 - (6) Test equipment used and associated serial numbers.
 - d) Analog output devices:
 - (1) Calibration range.
 - (2) Test value at each test point.
 - (3) Analog output associated PLC register address.
 - (4) Control variable value at field device at each test point.
 - (5) Physical device response at each test point:
 - (a) Response to be actual valve position, or motor speed, etc.
 - (6) Test equipment used and associated serial numbers.
 - 10) Failure testing:
 - a) Demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
 - (1) Equipment failure.
 - (2) Communications sub-system error.
 - (3) Power failure.
 - (4) Process equipment failure.
 - (5) High system loading conditions.
 - 11) Engineer approval of the CEET submittals is required before proceeding to Functional Testing.
6. Functional testing:
- a. General:
 - 1) Testing to demonstrate proper operation of systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.

- 2) Performed by Contractor, ICSC, and manufacturer's representative working together, with assistance from the OWNER or the inspection staff, as needed.
 - 3) Additional tests are specified in other Instrumentation and Control Sections.
 - 4) Follow approved detailed test procedures and check lists for Functional Test activities.
- b. Control logic operational validation:
- 1) The purpose of control logic validation is to field test the operation of the complete control system, including all parts of the HMI/SCADA system, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
 - 2) Demonstrate control functionality shown on the P&IDs, control schematics, and other drawings, and specified in the loop descriptions, control strategies, Electrical Specifications, and Mechanical Equipment Specifications.
 - 3) Test in detail on a function-by-function and sentence-by-sentence basis.
 - 4) Thoroughly test hardware and software functions:
 - 5) Including all hardwired and software control circuit interlocks and alarms.
 - 6) Test final control elements, controlled equipment, control panels, and ancillary equipment under startup, shut down, and steady-state operating conditions to verify all logic and control is achieved.
 - 7) Control logic validation tests to include, but not limited to: a repeat of all control logic tests from the FAT, modified and expanded to include all field instruments, control panels, circuits, and equipment.
- c. Loop tuning:
- 1) Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
 - 2) Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve 1/4-wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
 - 3) If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.
 - 4) Functional validation sheets:
 - a) Document each Functional test on an approved test form.
 - b) Document loop tuning with a report for each loop, including two-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the

- Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by Contractor and Engineer.
- c) Include on the form, functions which can be demonstrated on a loop-by-loop basis:
 - (1) Loop number and P&ID number.
 - (2) Control strategy, or reference to specification tested.
 - (3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the Functional test. Otherwise, create new forms.
 - d) For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
 - (1) Specification page and paragraph of function demonstrated.
 - (2) Description of function and/or text from specification.
 - (3) Test procedures: use the FAT loop test checklist forms modified to meet the specific testing conditions of the Functional test.
- 5) Functional certification:
- a) Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in the Contract Documents.
 - (1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all Functional test requirements have been satisfied.

C. Process Start-up Phase:

- 1. Process Start-up:
 - a. ICSC shall be onsite to support Process Start-up activities and provide functional changes as required.
- 2. Process Operation Period:
 - a. ICSC shall be available to support Process Operational Period and provide functional changes as required.
- 3. Instrumentation and Controls Fine-Tuning:
 - a. General:
 - 1) After the Process Operational Period, test PCIS system for additional 60 days as specified in this Section to identify issues and make corrections, as needed.
 - 2) The performance test is part of the Work that must be completed as a condition of substantial completion and final completion for the entire Project.
 - 3) The complete PLC control and HMI/SCADA system must run continuously for the duration of the performance test.
 - 4) Test and use the entire process control system under standard operating conditions.
 - 5) Exercise all system functions.
 - 6) Log failure, any system interruption and accompanying component, subsystem, or program failure including time of occurrence, duration of each failure, failure classification, and cause:

- a) Provide a competently trained technician or programmer on call for the Project Site during all normal working days and hours from the start of the performance test until final acceptance of the system.
 - (1) Response time to the Project Site: 24 hours or less, for a major failure.
 - b. SCADA system testing:
 - 1) Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
 - 2) Failure of the HMI/SCADA system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications.
 - a) Corrective action is required before restarting the performance test.
 - 3) Only those components, sub-systems, and systems covered in this Section and supplied under this Contract shall be considered for this acceptance test. Problems and failures of other systems shall not be considered as part of this test, except as they display the capabilities of this system to detect failures.
 - 4) Failures:
 - a) Classify failures as either major or minor:
 - (1) Minor failure:
 - (a) A small and non-critical component failure or software problem that can be corrected by the Owner's operators.
 - (b) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
 - (c) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
 - (d) Failure of one printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and repairs can be made and equipment returned to service within 3 working days.
 - (2) Major failure:
 - (a) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
 - (b) Cause termination of the performance test.
 - (c) Start a new acceptance test when the causes of a major failure have been corrected.
 - (d) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.
 - 5) Technician report:
 - a) Each time a technician is required to respond to a system malfunction, they must complete a report, which includes details

concerning the nature of the complaint or malfunction and the resulting repair action required and taken.

- b) If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
- c) If a technician has performed work but no report is written, then a major failure is considered to have occurred.
- d) Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

3.08 FIELD QUALITY CONTROL (NOT USED)

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES

A. Example test forms:

- 1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of Project-specific test forms for this Project.
- 2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	
1. GENERAL INSPECTION A. Structural Inspection ☐ Verify Lifting Lugs Installed ☐ Verify enclosure has lock and lock is functional ☐ Confirm that seismic bracing components are provided per manufacturer's installation instructions B. Exterior Inspection ☐ Cabinet exterior is clean, scratch, and dent free ☐ Inspect externally for corrosion and damage ☐ Verify enclosure door opens and closes easily ☐ Verify enclosure has a 3-point latch ☐ Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet) ☐ Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc.) ☐ Verify enclosure is the appropriate size (not grossly larger than design, and will still fit in the plant) Nameplates ☐ Cabinet has identification nameplate ☐ All door labels are straight, spelled correctly, and match the tagging defined in the Contract ☐ Cabinet has a nameplate that includes the following: ☐ Power source(s) ☐ Integrator's Logo ☐ Circuit ID(s) ☐ Short Circuit KAIC ratings ☐ If labels are screwed to door, silicone was utilized to cover screw holes (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.) Door Devices ☐ All devices penetrating the outside of panel have gaskets, silicone or both ☐ All door devices are installed (HMIs, Pilot Devices, etc.) ☐ Door mounted equipment is mounted straight and square ☐ All exterior or door mounted equipment present and accounted for, installed and securely fastened ☐ NEMA classification has not been violated due to penetrations ☐ Door mounted equipment has the same NEMA rating as the panel ☐ All door mounted equipment installed at the correct height ☐ All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner) ☐ Doors with multiple penetrations have adequate bracing (if needed) ☐ Visually check condition of indicators , controllers and annunciators ☐ Check that pilot lights illuminate correctly ☐ Check the Push-To-Test function ☐ Ensure correct pilot light color Peripheral Devices ☐ Horn / Beacon is installed (where required) ☐ Silence and Reset pushbutton		
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____		TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____

	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
1. GENERAL INSPECTION (continued) C. Interior Inspection ☐ Cabinet is cleaned of marks and dirt. ☐ Inspect internally for corrosion and damage. ☐ Back panel is clean of marks and dirt. ☐ Interior of panel vacuumed and shall be free of all debris. ☐ Check that the panel roof is clean and clear of foreign materials. ☐ Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed. ☐ If internal light door limit switch is provided, ensure the light automatically turns "on" when the doors are open. ☐ Check that a document pocket has been provided. ☐ Intrusion alarms (where required). Interior Labeling ☐ All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags. ☐ Verify that door mounted components are mounted square and symmetrical. ☐ Verify that nameplates are straight, legible, and spelled correctly. ☐ All terminal blocks are identified/labeled with permanent labels including tight end blocks and caps. ☐ All wiring shrink labeled and or phased correctly to the specifications. ☐ All wire labels shrunk completely rotated and aligned alike for easy identification. ☐ All fuses and circuit breakers are labeled with ID and current rating. ☐ System Integrator's label or labels installed on door. ☐ Panel manufacturer model/serial number tag is present. ☐ All required safety/warning tags installed and straight. ☐ Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight (the UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.). Wireways ☐ Plastic wire way covers installed properly. ☐ Plastic wireways have no sharp edges. ☐ No wire Ties inside the wireways. ☐ No sharp edges on wire ties. ☐ Separation: White duct is used for DC voltages, Gray duct is used for AC voltages. ☐ Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.												
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">PROJECT NAME: _____</td> <td style="width: 50%; border: none;">TEST DATE: _____</td> </tr> <tr> <td style="border: none;">FACILITY NAME: _____</td> <td style="border: none;">TESTED BY: _____</td> </tr> <tr> <td style="border: none;">PROCESS AREA: _____</td> <td style="border: none;">COMPANY: _____</td> </tr> <tr> <td style="border: none;">NETWORK ID: _____</td> <td style="border: none;">PAGE: _____</td> </tr> <tr> <td style="border: none;">WITNESSED BY: _____</td> <td style="border: none;">SIGNATURE: _____</td> </tr> </table>			PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
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	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
1. GENERAL INSPECTION (continued) C. Interior Inspection (continued) Wiring ☐ Visually check terminals and condition of internal wirings ☐ Verify that the control panel has been assembled and wired as designed ☐ Verify that all components are operational and perform the functions intended ☐ Verify that all components are sized appropriately for the application ☐ Verify that equipment control circuits function as intended ☐ Back of door wiring is labeled and neatly formed ☐ Back panel to door wiring has sufficient bending radius with spiral wrap ☐ Wire connection has been verified wired to correct points within the panel ☐ Individual wires have been given a pull test to verify a good terminal connection ☐ Wire and cable minimum bending radius have not been violated ☐ All equipment installed straight and square to back panel ☐ Wire colors are correct: ☐ Black and White > AC hot and neutral, respectively ☐ Red > AC control signals ☐ Blue > DC power and control (Blue w/White stripe for DC ground) ☐ Yellow > Foreign voltages (those still present when panel power is disconnected) ☐ Green > AC equipment ground ☐ Black > TSP (+) ☐ White > TSP(-) ☐ Analog wiring shields are continuous (connected by a dedicated terminal block for such shields) ☐ Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself ☐ Discrete inputs are separately fused or protected by a circuit breaker on a "per loop" basis ☐ Intrinsic Safety Wiring ☐ Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring ☐ Verify all spare terminals are installed according to the percentage listed in the specifications Grounding ☐ Equipped with "Blackburn" or other grounding type lug ☐ Lug is securely fastened to the panel structure ☐ Verify Grounding bar is installed ☐ Verify Isolated ground bar is installed												
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	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
2. POWER TEST A. AC Power ☐ AC Power is routed correctly within the panel, and is isolated from DC and network wiring. ☐ All fuses are installed and sized properly. ☐ All breakers are installed and sized properly. ☐ 24 VDC Power Supplies are functional. ☐ 24 VDC Power fail contacts are functional. ☐ 24 VDC power supplies are redundant, and have diode modules enabling the hot swap-over between supplies. ☐ 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional. ☐ Dedicated receptacle is wired to receive a dedicated AC supply. ☐ Verify continuity for all DC commons, ground and AC neutrals. ☐ Verify that the CP temporary input power is connected correctly and is the correct voltage. ☐ Close the CP main circuit breaker(s). ☐ Verify that voltages at subsequent circuit breakers are correct. ☐ Close circuit breakers. ☐ Verify that power feeding interruptible and uninterruptible power supplies is correct. ☐ Turn on power supplies if they are not already on. ☐ Verify that voltages at distribution terminals are correct. ☐ Energize any remaining hardware such as the PLC. B. Uninterruptible Power Supply (UPS) ☐ Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel. ☐ Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit). ☐ Test all UPS alarms (on inverter, failure, battery failure etc.) ☐ Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel. 3. CONTROLS & AUXILIARY DEVICES TEST ☐ Verify all interposing and auxiliary relays are functioning. ☐ Verify panel lights are functioning. Ventilation and Heating ☐ If ventilation fans are fitted, check the fans operate correctly any associated air filters are clean and not blocked. ☐ Verify components are installed in the correct orientation for proper air flow. 4. HARDWIRED INTERLOCK AND SAFETY TEST ☐ Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump. ☐ Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.												
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	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
5. PLC TEST A. Components ☐ PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional. ☐ Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used. ☐ TVSS is installed across the main incoming 120 VAC. PLC and PLC Rack ☐ Verify all cards are securely seated. ☐ Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the "no encroachment" area. Confirm with manufacturer clearance recommendations. B. PLC I/O Test ☐ Furnish I/O test forms and test all the listed input and output points as follows: ☐ Discrete Inputs: Simulate a field contact closure by "shorting" across the appropriate terminal blocks. Observe the transition between a logical "0" and "1" in the PLC software. ☐ Discrete Outputs: Force the output bit to toggle between logical "0" and logical "1" using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the "ohms" setting. ☐ Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred. ☐ Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter. C. Redundant Controllers (where required) Test ☐ Remove Communication cable from primary PLC to verify switching to backup PLC ☐ Remove Communication cable from backup PLC to verify switching back to primary PLC ☐ Remove Power cable from primary PLC to verify switching to backup PLC ☐ Remove Power cable from backup PLC to verify switching back to primary PLC D. PLC Control Logic Verification ☐ The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below. ☐ ☐ ☐ DI states are either simulated by hardwired switches or forced inputs using a programming terminal. ☐ For example, when starters and drives are not provided as part of the contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.												
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	FACTORY ACCEPTANCE TEST - CONTROL PANELS	
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5. PLC TEST (continued)

D. PLC Control Logic Verification (continued)

Typical Fault Logic

☐ If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears.

☐ The fault condition must return to normal and the alarm must be reset for a latched alarm to clear.

Typical Fail to Start Logic

☐ If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm.

6. HMI OR OIT TEST

HMI / OIT Functionality

☐ Communication with PLC

☐ Screen Layouts

☐ Screen Navigation

☐ Set Point Entry

☐ Animation

☐ Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention)

☐ Alarms

☐ Acknowledge and Reset

☐ Security / Access Levels / Passwords

7. NETWORK COMMUNICATION TEST

A. Network Components

☐ Fiber optic cabling terminates in a patch panel

☐ Media converters are installed and functional

☐ Terminating resistors have been installed for trunk/tap topologies or where required

☐ Wire and cable bending limitations have not been violated

B. Networking Functions

☐ Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams

☐ Verify network traffic rate and error margin is acceptable

PROJECT NAME: _____	TEST DATE: _____
FACILITY NAME: _____	TESTED BY: _____
PROCESS AREA: _____	COMPANY: _____
NETWORK ID: _____	PAGE: _____
WITNESSED BY: _____	SIGNATURE: _____

	FACTORY ACCEPTANCE TEST - CONTROL PANELS			
8. FAT DOCUMENTATION AND RECORD Panel Documentation ☐ As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material. ☐ Panel schematic and interconnection drawings. ☐ P&ID drawings and schematic drawings for the process area controlled by the panel that is to be tested. ☐ I/O list test forms of the process area to be tested. ☐ FAT procedure of the process area to be tested. ☐ Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel. ☐ Hard copy of the PLC application program of the process area to be tested. ☐ Hard copy of the HMI/OIT graphic screens of the process area to be tested. 9. FAT TOOLS AND SOFTWARE ☐ Simulation software if required ☐ Digital volt meter Fluke 87 ☐ Process meter Fluke 787 ☐ Laptop computer with PLC application program ☐ Temporary SCADA computer with HMI software and applicable graphic screens ☐ Jumper wires				
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	INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	
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INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION
CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

REMARKS: _____

CHECKED BY (COMPANY) _____	ACCEPTED BY (COMPANY) _____
SIGNATURE _____	SIGNATURE _____
DATE _____	DATE _____

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	
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INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER DETAIL NO. _____
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

<u>FIELD CALIBRATION CHECK</u>						
CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR	ACTUAL TRIP POINT WAS	
1	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	
2	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	
3	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	
4	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	
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☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

INSTRUMENT TYPE
INDICATOR

☐ TRANSMITTER

☐ CONTROLLER

☐

☐ OTHER

DESCRIPTION

INSTRUMENT TAG NO.

SERIAL NO.

SERVICE
DESCRIPTION

BENCH CALIBRATION CHECK

INPUT RANGE = _____			OUTPUT RANGE = _____	
HEAD CORRECTION = _____			☐ LINEAR	
CALIBRATED SPAN = _____			☐ SQUARE ROOT	
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

FIELD CALIBRATION CHECK

INPUT RANGE = _____			OUTPUT RANGE = _____	
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	
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- ☐ DIRECT ☐ REVERSE
☐ ACTION VERIFIED AT 50% SPAN
☐ ACTION VERIFIED AT _____ SPAN

CONTROLLER SETTINGS								
SETTING	GAIN	PB	RESET (INTEGRAL)	DERIV. (RATE)	HIGH LIMIT	LOW LIMIT	ELEV. ZERO	ZERO SUPP
PRE-TUNE								
POST-TUNE								

PRE-TUNE SETTINGS					
	GAIN	PB	RESET (REPEAT/MIN)	RESET (MIN/REPEAT)	DERIVATION (MINUTES)
FLOW	1.0	100	10	0.1	N/A
LEVEL	1.0	100	MIN.	MAX.	N/A
PRESSURE	2.0	50	2.0	0.5	N/A
TEMP.	4.0	25	0.1	10	OFF

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST	
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☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

TYPE OF INSTRUMENT _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, IF TRUE

☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____

☐ VERIFIED PER P&ID NO. _____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____

☐ INSTALLATION CORRECT PER DETAIL NO. _____

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	
--	--	--

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

- ☐ VALVE TAG NO. _____ SERIAL NO. _____
- ☐ TRANSDUCER TAG NO. _____ SERIAL NO. _____
- ☐ SOLENOID TAG NO. _____ SERIAL NO. _____
- ☐ VOLUME BOOSTER TAG NO. _____ SERIAL NO. _____
- ☐ POSITIONER _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

TRANSducer CHECK					
INPUT RANGE =			OUTPUT RANGE =		
CALIBRATED SPAN =			CALIBRATED SPAN =		
BENCH					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		
FIELD					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		

CHECK BELOW, IF TRUE:

- ☐ BENCH CALIBRATED PER ABOVE _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ VALVE SPECIFICATION NO. _____
- ☐ TRANSDUCER SPECIFICATION NO. _____
- ☐ SOLENOID SPECIFICATION NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS _____
- ☐ VALVE DETAIL NO. _____
- ☐ TRANSDUCER DETAIL NO. _____
- ☐ SOLENOID DETAIL NO. _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	
--	--	--

- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

VALVE CHECK			
FLOW CHECK	☐ PROCESS FLOW DIRECTION THROUGH THE VALVE IS CORRECT		
SAFETY CHECK	ON LOSS OF AIR VALVE FAILS ☐ OPEN ☐ CLOSE		ON LOSS OF POWER SOLENOID FAILS ☐ TO VENT ☐ TO VALVE
TRAVEL CHECK	FULL OPEN AT _____ PSI	FULL CLOSED AT _____ PSI	MEASURED TRAVEL _____ INCHES
SEATING CHECK	☐ ON BENCH ☐ IN-LINE	RESULTS	ACTUATOR BENCH SET
POSITIONER CHECK			
VALVE FULL OPEN AT _____ PSI TO POSITIONER			
VALVE FULL CLOSED AT _____ PSI TO POSITIONER			
VOLUME BOOSTER CHECK			
BYPASS VALVE (GAIN) ADJUSTING SCREW BACKED OUT _____ TURNS FROM CLOSED TO ENSURE QUICK BUT STABLE OPERATION (TYPICALLY 1-1/2 TO 2 TURNS)			

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

