

SECTION 40 99 90
PACKAGE CONTROL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Scope:

1. This section specifies additional requirements for Supplier packages including electrical components, electrical systems, control system hardware/software, all associated process instrumentation, all testing, and all other requirements for a completed system. The Supplier Package Control System shall include all electrical system components and control system components required for a complete, fully functional and operable control system including panels, power supplies, programmable logic controllers (PLCs), input/output (I/O) systems, interconnect wiring, communication interfaces, networking devices and instruments. The Supplier package control system shall include all coordination, configuration, testing and any other items required for a complete, fully functional and operable control system interface to Plant Control System (PLC and SCADA). The Supplier package control system shall be provided with system operations and maintenance manuals, user guides, troubleshooting guidelines, and system configuration documentation. Supplier shall also supply backup software and software licenses, and provide fully programmed package system control strategies, hardwired and networked I/O, PCS network interface and data communications, and dynamic operator graphics including process graphical representations of the Supplier package system, control graphics (if applicable) alarm logs, trends, and reports in accordance with the Supplier package system equipment specifications, Division 40, Process Interconnections, and the Drawings.
2. This section specifies general requirements which are applicable to providing a completed Supplier package control system. A completed Supplier package control system includes a complete, functional process control, instrumentation, communication, and signal system within the Grand Canyon South Rim Wastewater Treatment Plant.
3. This section specifies requirements for the coordination between the Vendor Packaged Control Systems and the Plant Control System Integrator Supplier (PCSI) provided Plant control system.

B. Roles and Responsibilities:

1. Definitions:
 - a. For the purpose of this section, "Supplier" refers to the Package System Equipment Supplier.
 - b. For the purpose of this section, Process Control System (PCS) refers to the Supplier's Process Control System.
 - c. For the purpose of this section, Process Control System Integrator (PCSI) refers to the Plant Control System integrator.
2. Supplier's roles and responsibilities shall include the following:
 - a. Procure, assemble, configure, program, and test components of a Packaged System in the factory. Configuration and programming activities shall include provisions for the Plant Control System remote automatic control and Plant Control System remote manual control, as allowed by supplier and coordinated with the PCSI.
 - b. Ship the PCS to the Work Site and aid the Contractor in the physical installation of the PCS. Where required by the Contract Documents, this may include coordination of all external connection points like conduit, wiring, piping, and other services where required.
 - c. The Suppliers shall provide onsite testing, startup, and commissioning services for the purposes of ensuring the Package System performs the functions required in the Contract Documents.
 - d. The Supplier shall attend software integration workshops with the Plant Control System Supplier and Contracting Officer's Representative, for the purposes of integrating the control system supplied with the Package into the Plant control system.
3. Contractor's roles and responsibilities shall include the following:
 - a. Where required by the Contract Documents, the Contractor shall install all components of the Package System as recommended by the Supplier, and/or Contracting Officer's Representative.
 - b. Coordination between the Suppliers, the Contracting Officer, PCSI and other subcontractors for submittals, factory testing, field testing and commissioning activities.
4. Contracting Officer's roles and responsibilities shall include the following:
 - a. Validate that all features of the Package Systems have been successfully integrated and tested with the Plant Control System.
 - b. Validate that all features of the Package System have been successfully integrated and tested with the MCCs.

C. Hardware and Software:

1. Supply all package control system components as well as any ancillary, or incidental equipment or devices, whether identified or not, that are required to monitor and control the Supplier package system process equipment from the local Supplier package control operator interface on the Supplier panel, and from the plant control system. The hardware and software shall:
 - a. Come with fully programmed controllers and HMI that provide the control strategy functions and operations interfaces as specified in the equipment specification, adhere to Project's programming standards. Shall include all display and control strategy programming requirements and standards. Shall include control and communications capabilities to restart the package control system and the package system equipment as required after a plant shutdown or power failure in coordination with and as commanded by the plant control system.
 - b. Provide the required PCS interfaces as specified for each of the Supplier package systems. Provide programmed network interfaces to the PCS, which allow monitoring and control of all Supplier package control system I/O and virtual data points from the PLANT CONTROL SYSTEM using one of the protocols specified herein.
 - c. At a minimum, store all alarms locally, until they are manually reset, through the PCS operator interface. This item shall be reviewed and coordinated with the PCS Supplier during software coordination.
2. All Application Software developed by PCSI becomes the property of NPS and may be modified, deleted, copied and reused for other functions or in other plants.

D. The Suppliers shall provide services to:

1. Design, fabricate, program, factory testing, PCS integration and testing, component testing, functional testing, pre-startup testing, startup testing, and acceptance testing to deliver a fully functional package control system that is acceptable to the Contracting Officer.
2. Program a fully functional package control system capable of exchanging hardwired and software inputs and outputs, alarms, and equipment sequence and controls interfaces with the PCS that complies with the equipment specifications, applications programming requirements of the Project. At a minimum this shall include:
 - a. Program all control logic required for the package system.
 - b. Program HMI screens, where required.
 - c. Test all control and software functions and features.

3. Provide coordination with the Project PCSI and provide the required network configuration as specified for the supplier package system.
4. Ensure that the PCSI has all the required information to safely implement remote control functions, as per requirements of the respective Supplier equipment specification. The Supplier shall also implement controls to protect personnel and equipment from damage.
5. Participate and execute the PCS Software Integration tasks and activities.
6. Provide the entire package control system, integration with the PCS, and all required training to the Contracting Officer as specified.
7. The Contractor will provide overall management and coordination of testing, start up, and commissioning. The Supplier shall participate with Contractor to execute the testing, start up, and commissioning of the supplier package control system and control of the supplier package system equipment.
8. Support the testing, start-up and commissioning of the supplier package system including the integration with the PCS.

E. Supplier Package System Software Integration:

1. The Supplier shall:
 - a. Provide detail logic and controls to automatically operate all package system equipment. Provide a package system PLC and HMI that shall interface to, and be integrated with, the PCS for supervisory control set points, command initiating points, monitoring and alarming as defined in the specific Supplier equipment specification, and programming requirements of the Process Control Descriptions. Provide documentation of a completed FDT for the control panel and PLC software.
 - b. Provide, participate, and execute Software Integration:
 - 1) Software Integration Workshop Submittals.
 - 2) Software Integration Workshops.
 - 3) Witnessed PLC/PCS Integration Operational Readiness Test (ORT).
 - c. Participate in the testing, commissioning, and startup activities of the PCSI supplied control system network that provides communications to the PCS.

F. Supplier's Field Services:

1. Installation of all package equipment, panels, controllers, and instruments
2. Field testing, Commissioning, and Field-testing Documentation:
 - a. Component testing.
 - b. Functional testing.
 - c. Pre-startup testing.

- d. Startup Testing:
 - 1) Performance testing.
 - 2) Optimization testing.
- e. Acceptance testing.

1.02 QUALITY ASSURANCE

A. Reference Codes and Standards:

1. This section contains references to the following documents. Those documents are a part of this section as specified and modified. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. References to documents shall mean the documents in effect at start of construction unless otherwise noted by a specific date noted in the listed reference below. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference Title	Specific Section and Paragraph, if applicable	Version, if other than latest as of July 2024
NFPA 70 National Electric Code	Entire Document	-
UL 508A Industrial Control Panels	Entire Document	-
UL 698A Industrial Control Panels Relating to Hazardous (Classified) Locations	Entire Document	-

B. Unit Responsibility:

1. The Supplier shall accept Unit Responsibility for equipment to warrant, design, manufacture, Factory Test, provide proof of seismic requirement compliance as required by this section, ship, provide coordination of installation, provide all specified Field Testing and Commissioning, Training, and Operations and Maintenance Manuals for all the equipment specified in this section. A Certificate of Unit Responsibility Form shall be furnished for the equipment specified in this section.

2. The package control system design, installation, testing, and commissioning work shall be provided by the package system Supplier. The system shall meet the qualifications of this section.
 3. Supplier shall be responsible for all hardware and software configuration to provide the established level of performance, redundancy and quality.
 4. Supplier shall provide onsite design reviews with the Contracting Officer, and onsite assistance, direction, and coordination during installation, functional testing, start-up, and commissioning of systems, and as needed through closeout.
 5. Applications Software Integration: Supplier shall coordinate with PCSI staff and the Contracting Officer to assure seamless integration with the PCS over an Ethernet network interface.
- C. Warranty: A warranty for the equipment specified under this section shall be provided in accordance with the Contract Documents. The Warranty shall be for 2 years from the date of the Notice of Substantial Completion certificate issued by the Contracting Officer.
- D. Listed Products:
1. Equipment and components shall be UL listed for the purpose or UL recognized.
 2. The control panels shall have factory applied UL 508A labels. Where intrinsic safety barriers are used within a control panel, provide UL 698A factory applied label as required by UL.
 3. All panels shall be labeled in accordance with NEC Article 409.
- E. Calibration: Following the Construction Contractor's installation of equipment, Supplier shall field calibrate all instruments where possible, including pressure transmitters, process analyzers, flow meters, switches. Instruments that cannot be field calibrated shall be factory-calibrated and supplied with written calibrated certification. Accuracy shall be checked in the field. Factory calibrations shall be traceable and stamped per this section.
- F. Onsite Installation Support, Component Testing, Functional Testing, Pre-Startup Testing, and Startup Commissioning:
1. Provide testing services coordinated per requirements of Section 01 91 14, Equipment Testing and Facility Startup.
 2. Qualified supplier personnel to supervise Contractor activities during commissioning, onsite performance testing, equipment start-up, training of Contracting Officer's staff, and follow-up testing services.
 3. Test Forms: Develop Test forms and procedures for all devices and all tests.

G. Package System Supplier Qualifications:

1. Supplier shall be regularly engaged in the design and installation of the supplier package process control systems and have a local installation and service organization experienced with the specified and submitted equipment.
2. The supplier shall provide a minimum of three references whose package process control systems, of similar complexity, have been designed and installed during the past 5 years, and are currently in full operation.
3. The supplier qualified staff and support organization shall:
 - a. Provide factory-trained supplier-authorized personnel to furnish technical direction for onsite labor associated with installation of the supplied equipment, landing of wiring/cabling, power wiring, grounding, field I/O wiring, and network cables for the supplier package control system equipment.
 - b. Provide a programming manager that has programmed the specified control system equipment for a minimum of 5 years or has programmed five separate supplier package control systems using the specified control system hardware and software. This experience would include management of the programming, start-up and commissioning of the package system. The supplier programming manager shall administer the supplier's quality assurance program which shall include:
 - 1) Definition of the package system control strategies, equipment and processes based on the Specifications and Drawings.
 - 2) Maintenance of an updated programming status.
 - 3) Updating of the program documentation.
 - 4) Updating the application program revision control procedures (in this section), and software.
 - 5) Attendance at onsite reviews as required by the Contracting Officer's Representative.
 - 6) Coordination with PCSI staff to define factory acceptance testing procedures and dates for demonstrating the supplier package system network interface with the PCSI Ovation PCS.
 - c. Provide programming personnel, with programming experience with the specified equipment.
 - d. Provide the names and qualifications of field support technicians who are capable of supporting the installed supplier package control system after formal acceptance by the Contracting Officer's Representative.
 - e. Provide trainers with classroom training experience with the specified equipment to provide the required system operations and maintenance training courses.

1.03 SUBMITTALS

- A. Preconstruction/Action Submittals: The following minimum submittals shall be submitted prior to construction of this element of the Work in accordance with Section 01 33 23, Submittal Procedures.
1. A copy of this section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate Specification compliance or marked to indicate requested deviations from Specification requirements or those parts which are to be provided by the Contractor or others shall be provided. Check marks (✓) shall denote full compliance with a paragraph as a whole.
 - a. If deviations from the Specifications are indicated, and therefore requested, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Contracting Officer shall be the final authority for determining acceptability of requested deviations.
 - b. The remaining portions of the paragraph not underlined shall signify compliance with the Specifications. Failure to include a copy of the marked-up sections, along with justification(s) for any requested deviations to the requirements of the Specification shall be cause for rejection of the entire submittal and no further submittal material will be reviewed.
 2. For all equipment specifications, a copy from the Drawings of the control diagrams and process and instrumentation diagrams (P&IDs) relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the diagrams shall be marked "no changes required." Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
 3. Certificate of Unit Responsibility attesting that the Contractor has assigned unit responsibility in accordance with the requirements of this section. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
 4. Systems:
 - a. Equipment literature, cut-sheets and data-sheets for all equipment supplied under this section.
 - b. Performance calculations.

- c. Dimensional drawings for the equipment supplied under this section. In addition to dimensional information for the equipment specified, these drawings shall dimensionally show the connection points and sizes for piping, electrical, instrumentation, water supply, and structural connections.
 - d. Weights for the provided equipment and major components.
 - e. Information regarding the materials of construction for all equipment supplied under this section.
 - f. Shop painting systems, including descriptive technical catalog literature and specifications.
 - g. Anchorage calculations demonstrating compliance with the requirements of Section 01 88 15, Anchorage and Bracing.
 - h. Special shipping, storage and protection, and handling instructions.
 - i. Installation Instructions.
 - j. System electrical elementary diagrams, internal connection diagrams, and external interconnection diagrams. Connection diagrams shall be the conventional type with lines showing point-to-point wiring and must show terminals and devices as viewed by the electrician; wireless or wire schedule types are not acceptable.
 - k. Catalog data on all ancillary electrical components, including limit switches and instruments.
 - l. Spare parts list.
 - m. Warranty information.
5. Control panel drawings including the following:
- a. Fabrication details and placement of operator interface devices and associated elements.
 - b. Panel heat load and dissipation calculations.
 - c. Scale drawings showing dimensions and location of panel-mounted devices, doors, louvers, and subpanels, internal and external.
 - d. Construction details showing panel NEMA rating, enclosure dimensions, panel configuration (e.g., type of mounting), panel material, internal backplane dimensions, detailed cable configuration and protocol configuration, and other construction details.
 - e. Instrumentation and control components schedule including item number, tag designations, nameplate inscriptions, instrument scale, and any other special information and remarks required for clarity.
 - f. Bill of materials indicating item identifier, tag number, description, model number, and quantity.

- g. Construction notes including panel wire color schemes, wire and terminal block numbering, and labeling scheme.
 - h. PLC-related items such as input/output (I/O) type and address, PLC rack number, PLC slot number, PLC point number, PLC number, and PLC equipment Supplier and part numbers.
 - i. Shop painting systems, including descriptive technical catalog literature and specifications.
 - j. As-built control panel drawings, loop sheets, control system hardware bill of materials, and wiring diagrams for the package control system as specified in this section.
 - k. Spare parts list as specified within this section.
 - l. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature which shall include make and model of instrumentation and components of control system.
 - m. Complete P&IDs, network interface drawings, electrical schematic and wiring diagrams, electrical ladder diagrams, interconnection diagram showing power and control interfaces among all system components, and instrument settings.
 - n. Control panel arrangement drawings. Include wiring and schematic diagrams, network equipment, mounting, location, and communication layout drawings.
 - o. Panel elementary diagrams of prewired panels. Include in diagrams control devices and auxiliary devices, for example, relays, alarms, fuses, lights, fans, and heaters.
 - p. Interconnection wiring diagrams that include numbered terminal designations showing external interfaces.
6. AutoCAD Format Drawings: Prepare drawings in AutoCAD, latest version at time of Offer, with borders and title blocks identifying the Project, system, revisions to the drawing, and type of drawing. Include a date and description for each revision of a drawing including the date and description of the revisions. Drawing prints shall be 11 inches by 17 inches with a minimum lettering size of 1/8 inch. Include final, as-built drawings as hard copy and electronic files, with electronic files submitted in “.dwg” file format.
7. Quality Assurance Submittal:
- a. Supplier Testing Manager and Technician Qualifications.
 - b. Supplier Programming Manager and Programming Technicians.
 - c. Supplier Training Team.
8. Package Control System Implementation Plan:
- a. Supplier project schedule including all submittals, testing, delivery, and training.
 - b. Supplier programmer, trainer and field service technician’s qualifications.
 - c. Supplier program manager’s qualifications.

- d. Interconnect drawings required for network diagrams for communications between package control system and the PCS, as specified herein, and on the Drawings.
 - 9. Software Submittals:
 - a. Configuration files, logic files, and programming software.
 - 1) Documentation for HVAC controllers, individual module hardware configuration, software configuration, jumper positions, network switch configurations, HMI and PLC program files, and final addressing of all nodes for all communication networks interfaced to the package system.
 - 2) Programming software shall be identical to the software used to develop the package control system logic program or HVAC controllers.
 - 3) Provide programming software licenses as required for HMI systems.
 - 10. Instrument Submittals:
 - a. Instrument schedule.
 - b. Instrument data sheets based on ISA instrument data sheet format, with one instrument per data sheet.
 - 11. Passwords: Provide Contracting Officer with list of passwords and corresponding user level for each control panel and equipment that requires a passcode entry to make adjustments.
- B. Informational Submittals: The following minimum informational submittals shall be submitted in accordance with the timing requirements specified in these Contract Documents, prior to Substantial Completion and in accordance with Section 01 33 23, Submittal Procedures.
- 1. Operations and Maintenance Manuals (including Warranty) in accordance with Section 01 78 23, Operations and Maintenance Data. Manual shall include final reviewed submittal and separate record of all final configuration files and settings, jumper and switch settings, and network configuration settings.
 - 2. Factory Test Reports.
 - 3. Witnessed Test Reports.
 - 4. Certificate of Proper Installation Forms, Documents, and Reports.
 - 5. Field Test Forms, Documents, and Reports.
 - 6. Certificate of Field Testing and Commissioning.
 - 7. Certificate of Training Completion.

1.04 WORK BY OTHERS

- A. Unless otherwise specified in Division 40, Process Interconnections, the following items will be supplied by others:
1. Control network will be supplied by Division 40, Process Interconnections.
 - a. Joint testing between the Supplier and Division 40, Process Interconnections, includes: Network communications to/from Supplier system and the plant network.
 2. Electrical room and associated environmental conditioning.
 3. Power, data and signal interconnects including wiring, conduit, tray, and other appurtenances required to provide connections between the package control system and the PCS. Supplier shall still provide testing and coordination for package system interfaces to, and from PCS.
- B. In general, Supplier package equipment and instrumentation are shown on the PIDs. A subset of all Supplier items to be included is shown inside a Supplier box or labeled with an asterisk. Cabling between the Supplier equipment and non-Supplier instrumentation and instrument and control panels shall not be provided or installed by the package system Supplier. Additional instruments provided by the Supplier that are not shown on the Drawings shall be coordinated by the Supplier.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

- A. Suppliers:
1. Refer to acceptable products in each equipment specification.
 2. All products herein shall be coordinated at the time of submittals.
 - a. The actual submitted model numbers, and versions, shall be the latest version at the time of submittals, or approved otherwise, at the time of submittal.
- B. Supplier Qualifications: Refer to each equipment specification.

2.02 MATERIALS

- A. Materials used for the construction of the equipment provided under this specification shall be as follows:
1. Enclosures: Rating and material requirements shall be in accordance with the Area Classification Table and Material Selection Table on the Drawings.

2. Instruments: Rating and material requirements shall be in accordance with the Area Classification Table and Material Selection Table on the Drawings.

2.03 EQUIPMENT

- A. The Supplier package controller shall be as defined hereinafter.

2.04 ELECTRICAL COMPONENTS AND ACCESSORIES

- A. Physical Characteristics:

1. Electrical components and control panels shall be listed for the purpose for which they are to be used by an independent testing laboratory acceptable to the inspection authority having jurisdiction per Division 26, Electrical.
2. Electrical components shall be tested per the requirements specified in Section 01 91 14, Equipment Testing and Facility Startup, and Division 26, Electrical.
3. Where a motor is specified, unless otherwise indicated, the motor shall be provided in accordance with Division 26, Electrical.
4. Where a control panel is specified under this section, panels shall be UL 508A labeled and, unless noted otherwise, shall be rated for an available fault duty of 42,000 amps at 480 volts or 22,000 amps at 240 volts or less.
5. Where a control panel is specified under this section that include both power and controls components, where power components are defined as electrical components operating at above 120V ac nominal line to ground or line to line, the panel shall be provided with physical separation between the power and controls components as specified in Division 26, Electrical.
6. Electrical equipment shall include arc flash hazard labels as specified in Division 26, Electrical.
7. Where a control panel is specified under this section, the control panel provided under this section shall include integral, lockable power source disconnecting means for each source of power to the panel. There shall be no more than one main control panel for each package system unless noted otherwise in this specification section. The single main control panel shall have no more than three sources of power with one power source being the main power supply, and the other power sources being control power supplies. Power and controls circuits for the system control panel is provided under this Contract as indicated on the process and instrumentation diagrams (P&IDs). Any power sources that are

required beyond what is shown on the P&IDs shall be derived via power conversion equipment included in this system package including:

- a. 120V ac circuit, non-UPS, for all auxiliary systems within the panel including the panel light, receptacle, heating, fan, and other similar items as required.
 - b. 120V ac UPS power for PLC, OIT, DC power supplies, ethernet switches, and instrumentation.
 - c. 24V dc power supply for PLC output and input control power.
8. All factory wiring required for equipment specified under this section shall be included and shall have been tested for installation integrity as part of factory testing specified in this section.
 9. Field installed raceway and wiring required for the functional operation of the equipment specified in this section is defined on the electrical drawings and schedules based on the first named equipment Supplier specified in this section. Any additions or modifications to field wiring, raceway requirements, upstream overcurrent protection, related motor controllers or variable frequency drives being provided for the operation of driven equipment included in this specification shall be included under the work of this section and shall be installed per the specified requirements of the Division 26, Electrical, specifications.
 10. Provide nameplates on electrical equipment and control panels (where included under this section) as specified in Section 26 05 02, Basic Electrical Requirements.
 11. General: Skid- mounted components in the package shall be prewired to a terminal junction box located on the package equipment skid. Provide separate junction boxes for power, control and signals terminations.

B. Functional Characteristics: None.

C. Performance Characteristics: None.

2.05 INSTRUMENTATION AND CONTROLS

A. Physical Characteristics:

1. General:
 - a. Control system equipment shall be new, and unused, and shall conform to the requirements specified in this section.
 - b. Package control system hardware and wiring shall be arranged such that the equipment associated with one process train can be removed from service without affecting any other process train. Unless, specifically noted within the Supplier equipment specification, redundant hot-backup PLC processors shall not be used to meet this requirement. For multiple train package systems, provide a dedicated PLC system for each process train.

- c. Provide identical package control system hardware and software configuration, process control logic program, and HMI graphical interfaces for parallel equipment within a process or equipment of the same type distributed over multiple processes.
 - d. Provide a list of package control system I/O to the Contracting Officer.
 - e. Panels and components shall be as specified in this section.
 - f. Ethernet addresses, or addressing for package system PLCs, will be supplied by the Contracting Officer's Representative. Should Ethernet addresses have not been assigned at the time of preoperational (factory) testing, Contractor may choose temporary IP address assignments or request them from the Contracting Officer prior to testing.
 - g. All package system valves and instruments shall have a unique tag name and unique tag number as shown on the Drawings. If no tag name, or number, has been assigned, submit a tag name, and number, that is consistent with Contracting Officer's tag naming convention as presented in P&IDs. Provision of a cross-reference table charting non-standard Contractor assigned tags matching Contracting Officer's tag name standard is not acceptable.
 - h. The package control system input/output addressing assignments shall be developed by the package system Supplier. I/O assignments and tag naming by the Supplier shall be coordinated with and adhere to Contracting Officer's tag naming format. The Contracting Officer shall be kept appraised of changes in input/output point quantities and assignments as programming progresses.
 - i. Electrical material and equipment shall have UL 508 listing wherever standards have been established by that agency, whenever applicable. Complete electrical assembly shall meet all requirements of the National Electrical Code, National Electrical Suppliers Association (NEMA), National Fire Protection Association (NFPA), all applicable state and local codes, and requirements of Division 26, Electrical, the package system equipment specification, and this section.
 - j. Control strategies based on what is specified in the package system equipment specification shall be documented. All control strategies, updated schedules, and all other modifications required for complete package system, including interface to the PCS shall be updated to reflect Supplier control system.
2. Controller System:
- a. Controller:
 - 1) The PLC processors shall be sized with sufficient memory to process the package control system application control strategies, including all hardwired I/O, all PCSI monitoring and control I/O, while also providing memory for a

- 100 percent expansion of processing and memory capacity. Provide latest version at time of Offer with processor memory sized for twice the tested and completed PLC program.
- 2) PLC power supplies shall be sized for the PLCs and connected devices.
 - 3) PLC I/O: All discrete and analog I/O modules shall be individually isolated inputs and outputs.
 - 4) Discrete I/O:
 - a) Inputs shall be 24V dc. Discrete outputs shall be rated for 2 amps at 24V dc, minimum. Each input and output shall have an LED ON/OFF status indicator.
 - b) Outputs for Interface to External Equipment and Systems:
 - (1) Provide dry contact interface using one of the following methods:
 - (a) Provide relay type discrete output module.
 - (b) Power interposing relay to generate dry contact.
 - (c) Interposing relay is required for all digital outputs that control motor contactors.
 - 5) Analog Inputs and Outputs:
 - a) 4 mA dc to 20 mA dc per channel.
 - b) HART capable.
 - 6) Provide a minimum of 25 percent spare I/O of each type.
 - 7) All spare I/O shall be wired to panel terminal blocks.
 - 8) Provide a minimum of 20 percent empty slots in PLC racks/chassis, with a minimum of one each I/O card type.
 - 9) Provide PLC rack mounted Communication Module for interfacing with Plant Control System (PLC and SCADA).
 - 10) All PLC control logic and HMI configuration programs shall provide the functionality, content, format and documentation specified in equipment specifications.
 - 11) Minimum of 25 percent, wired, excess capacity for inputs, outputs, internal memory, and other necessary functions.
3. Communications:
- a. Communications with PCS:
 - 1) Communication via communication module that plugs in to the main processor rack.
 - 2) The Supplier shall program the IP addresses, Subnet masks, and gateway for all Supplier devices, including Supplier laptops, prior to the leaving the factory and prior to PCS ORT. IP addresses shall be provided to the Supplier from the Contracting Officer.

- 3) Communicated Data:
 - a) All alarm conditions.
 - b) All equipment running status.
 - c) All valve open and close status.
 - d) All driven, or operated, equipment including valves, pumps, motor, or similar REMOTE (or AUTO) status.
 - e) All process data such as level, flow, pressure.
 - f) Any control of Supplier system equipment from the PCS as specified in the equipment specifications.
 - g) Any operations setpoints to the Supplier system from the PCS as specified in the equipment specifications.
 - h) Additionally, as specified in equipment specification.
- b. Ethernet Communication with HMI and other equipment supplied by the packaged system.
 - 1) The PLC shall be equipped with a minimum of two Ethernet communication modules and ethernet switches to separate PCSI network traffic from other Ethernet traffic.
 - a) One module and ethernet switch will be dedicated to communication with the PCSI system.
 - b) One module and ethernet switch will be dedicated to HMI and other equipment supplied by the Supplier. This network shall not be interface to any networks outside the package system.
4. Control Panels:
 - a. Panel Fabrication:
 - 1) General:
 - a) Nameplates with tag number and equipment description shall identify face-mounted instruments. Instruments shall be mounted for access to components and ease of removal. Cutouts for future equipment shall be blanked off with suitable covers. Instrument tag numbers shall be identified on the panel rear.
 - b) Face-mounted equipment shall be flush or semi-flush with flat-black escutcheons. Face-mounted instruments that are more than 6 inches deep, weigh more than 10 pounds, or exert more than a 4-foot-pound moment force on the face of the panel shall be supported underneath at the rear by a 1-inch by 1/8-inch thick steel angle.
 - c) Panels less than 60 inches high shall be provided with floor stands to raise the top of the panel to 60 inches above the floor or work platform. Panels that weigh less than 100 pounds may be wall-mounted.
 - d) Panels with specified requirements including stainless steel or aluminum mounting requirements that are

indicated on the Drawings or on the Contract Details take precedence over the panel types or panel features indicated herein.

b. Panel Layout:

- 1) Provide 20 percent spare contiguous sub-panel area for future expansion.
- 2) Provide minimum of 20 percent spare terminal blocks, with a minimum of 10 analog, discrete, power.
- 3) Provide minimum of 12 inches clear space from the bottom of the panel to the bottom of the subpanel.
- 4) Separation between the power components (over 120V ac) and the control/instrument components (120V ac and less) by locating the power components and the control/instrument components in separate sections of the cabinet enclosure.
- 5) Power cabinet section and the control/instrument cabinet section with separate door handles.
- 6) Separation between the power components and the control/instrument components using barriers.
- 7) External lockable circuit breaker handle for the main panel disconnect.
- 8) Individual power and control components with internal circuit breakers, as required.
- 9) Motor controllers, as required by the equipment specifications.
- 10) Displays with door-in-door construction accessible by opening the cabinet outer door.
- 11) Face-mounted equipment flush or semi-flush with flat-black escutcheons.
- 12) Panel Tops of Wall-mounted Panels: Mounted at the same elevation.
- 13) Panel inner door contains a copy of the record elementary and wiring diagrams, or reference as allowed per NEC Article 409.
- 14) Panel inner door contains a drawing holder.
- 15) Panel drawings enclosed in a transparent, protective jacket.
- 16) Panel functions as specified.
- 17) Panels with floor stands, to raise the top of the panel to 60 inches above the floor or work platform.
- 18) Wall-mounting of panel weighs less than 100 pounds, where wall space is available,

c. Enclosures:

- 1) Panel enclosures shall comply with the requirements of NEC Article 409 and NEMA 250.

- 2) Enclosure rating and material requirements shall be in accordance with the Area Classification Table and Material Selection Table on the Drawings.
- d. Heating, Ventilating, and Cooling:
 - 1) Forced air ventilation shall be provided for panels if the cabinet's heat load calculations indicate that the interior temperature of the cabinet will exceed the rating of the device with the lowest temperature for that device within the enclosure, under worst case conditions.
 - 2) Ventilation for panel racks shall be venturi fans provided on 5-1/2-inch high-notched panel. Ventilation for consoles shall be similar to that for panel racks except EIA RS-310 mounting is not required. Fans shall be equipped with UL-approved washable filters and provide at least 240 cubic feet per minute (cfm). Fans shall be thermostatically controlled. Noise level at 3 feet from exterior wall and 30 degrees off axis shall not exceed 60 NC units.
 - 3) Outdoor panels shall also be provided with temperature and humidity controls:
 - a) Thermostatically controlled space heaters. Space heater surface temperature that exceeds 120 degrees F requires an expanded metal guard. Thermostats shall be Honeywell T631 series, Penn Controls A28AA-4.
 - b) Panel air conditioning cooling requirements shall be a cooling system that does not exchange cabinet interior air with ambient air. The cooling system shall be either a closed glycol loop heat exchange system or a CFC-free refrigeration system as required for the specified equipment and instrument complement and ambient temperature conditions.
 - c) Panel air conditioner shall be NEMA-rated based on the installed area environment.
 - d) The coils shall be coated and protected from corrosion.
- e. Nameplates:
 - 1) External door-mounted components and the panel description shall be identified with phenolic nameplates. Machine embossed metallic adhesive labels shall identify tag number of instruments inside panels. Nameplates shall be attached to panel surfaces, not to instruments.
 - 2) The machine engraved laminated black phenolic nameplates with white lettering shall be provided for panel-mounted equipment. Nameplate engraving shall include the instrument tag number and description in 3/32-inch minimum size lettering.

- 3) The machine embossed metallic adhesive labels shall identify tag number of instruments inside panels. Nameplates shall be attached to panel surfaces, not to instruments.
 - 4) The nameplates shall be attached to the panel with a minimum of two self-tapping Type 316 stainless steel screws. Provide RTV sealant for nameplates for NEMA 4X stainless steel panels.
 - 5) The nameplate wording may be changed without additional cost or time prior to commencement of engraving. Submit nameplate legend with the panel submittal.
- f. Panel Features:
- 1) Interconnection Wiring:
 - a) Panel Interconnecting Wiring:
 - (1) Panel Control Wiring: Single conductor stranded copper NEC rated Type MTW 16 AWG minimum (rated 10 A per NFPA 79, Table 12.5.1), with an exception for factory-supplied PLC wiring harnesses that are U.L. approved.
 - (2) Panel Instrument Wiring: Twisted 16 AWG shielded pair or tri conductors.
 - (3) Panel Power Wiring: Conductors specified in Division 26, Electrical, and meet the NEC requirements for power including phase, grounded, and grounding conductors.
 - (4) Wiring shall be supported independently of terminations by lacing to panel support structure or by slotted flame-retardant plastic wiring channels.
 - (5) Wiring channels shall comply with UL 94, Type V.
 - (6) Plastic wireway with covers shall be used to route groups of wires. Wireway fill shall be sized to provide 50 percent maximum fill.
 - (7) Plastic spiral wrap shall be used for exposed wires. Wires that cross door hinges shall be enclosed in plastic spiral wrap.
 - (8) Wiring color conventions and standards shall comply with the requirements in Division 26, Electrical.
- g. Wire Markers: Wire marker shall comply with the requirements specified in Division 26, Electrical.
- h. Conductor Identification:
- 1) Conductor identification shall comply with the requirements specified in Division 26, Electrical.

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

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

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

- 3) Conductor Identification:
- Wiring shall be tagged at terminations with machine-printed plastic sleeves with three-part wire numbers for instrument and control panel internal conductors:
 - Part-1: Prefix of the wire number shall be the instrument loop number or equipment tag number.
 - Part-2: Code letter and wire colors per panel standard.
 - Part-3: Number that identifies individual circuit conductor Terminal Number.
- i. Conductor Installation and Protection:
- Power and control wiring shall be carried in covered channels separate from low voltage signal circuits. An interior steel barrier shall be provided between AC control devices and the electronic equipment.

- 2) Terminal blocks shall be strap screw type rated for 600 volts. Each terminal trip shall have a unique identifying alphanumeric code at one end and a vinyl-marking strip running the entire length of the terminal strip with a unique number for each terminal. Numbers shall be machine printed and 1/8 inch high.
- 3) No more than two connections shall be made to one terminal.
- 4) Wire connectors shall be locking fork tongue or ring tongue insulated crimp type terminals.
- j. Field Wiring: Field wiring shall be connected to separate dedicated terminal blocks in a dedicated part of the panel where the field cables enter the panel. Provide a dedicated raceway on the field side of the terminal block for field wiring use only.
- k. Fuse and Fuse Holders:
 - 1) Fuses for 120V ac circuits shall have a minimum of 12,000 amperes interrupting capacity and blown fuse indicators.
 - 2) Fuses for 24V dc circuits shall be fast-acting glass tube type rated 1/8 amp or 1/10 amp for 4 mA to 20 mA loops.
 - 3) Fuses for 24V dc circuits shall be 1/2 amp for the power supply to individual instruments.
 - 4) Fuse holders shall be tip-out or draw-out type.
- l. Control Power:
 - 1) One 120V ac, UPS supplied circuit, for control power source: Dual, redundant with diode auctioneered outputs and automatic-switching between power sources, one for PLC and DC power and one for PLC output and input control power.
 - a) Provide control power transformers, as required for the load.
 - b) Provide direct current power supplies, as required for the load.
 - c) UPS power source for PLC and derived loop power as defined above, supplied to each control panel.
- m. Panel Utility Power Source:
 - 1) One 120V ac circuit, non-UPS, for all auxiliary systems within the panel including the panel light, receptacle, heating, fan, and other similar items as required.
 - a) Non-UPS circuit supplied to each control panel.
- n. Accessories:
 - 1) Panels greater than 24 inches high by 24 inches wide shall include GFCI convenience receptacles and fluorescent utility lights.
 - 2) Receptacles and utility lights shall not be powered by the UPS, where included.

- 3) Print pocket.
- 4) Fold-up shelf of sufficient size, sufficient weight capacity, and the proper angle for supporting a laptop computer.
- o. Fail-Safe Wiring: Fail-safe wiring of control relay or other on/off device or instrument provides the condition that will occur upon loss-of-power or internal failure in the device such that the relay is de-energized in the failure or loss-of-power condition such that the control relay contact operation provides for equipment failing in a safe mode.
- p. Control Devices: Control devices shall comply with Division 26, Electrical.
- q. Indicating Lights: Indicating lights shall be equipped with colored lenses as specified in Division 26, Electrical.
- r. Power Supply and Conditioning Equipment: Except for power supply units which form an integral part of an individual piece of equipment, all power supply and conditioning equipment shall comply with UL 1012 and shall be approved by UL, CSA, or FM for the application. All power supply equipment shall be provided in redundant configurations such that failure of a single unit will not disable all or any part of the instrumentation and communication systems. Diode isolation shall be provided for redundant direct current supply units, and the power supply negative output terminal shall be grounded.
- 1) Alternating Current (ac) Voltage Regulators:
 - a) Regulators shall be of the solid-state tap-changing type, insensitive to line frequency variations between 47 Hz and 63 Hz. Ferroresonant units are not acceptable. Output regulation for input voltage variation from 85 volts to 125 volts shall not exceed 3.3 percent. Output regulation for load variation from 0 percent to 100 percent shall not exceed 1 percent. Response time shall be 1.0 cycles or less. Voltage regulators serving panelboards and control panels shall have a load capacity not less than 200 percent of the connected load. Voltage regulators serving individual instruments shall have a load capacity not less than 125 percent of the connected load. Power loss in the regulator shall not exceed 2 percent of the regulator capacity, and harmonic distortion introduced by the regulator shall not exceed 0.1 percent. Regulator output shall be fully protected against internal faults, external overloads and short circuits. Three-phase units shall be four-wire, wye-connected, and capable of supporting 100 percent unbalanced load.

- 2) Noise-Suppression Isolation Transformers:
 - a) Isolation transformers shall be provided for AC-powered instrumentation loads containing solid state circuitry where such is not included within the instrument. Isolation transformers shall be of the triple box shield type. Each coil shall be completely enclosed in a grounded conductive faraday shield, and the overall transformer enclosed in a faraday shield. Common mode noise attenuation between primary and secondary shall exceed 140 dB at 1 kHz. Isolation transformer dielectric strength shall be 2,500 volts minimum. Isolation transformers serving panelboards and control panels shall have a load capacity not less than 200 percent of the connected load. Isolation transformers serving individual instruments shall have a load capacity not less than 125 percent of the connected load. Power loss in the isolation transformer shall not exceed 2 percent of the maximum load rating. Harmonic distortion introduced by the isolation transformer shall not exceed 0.1 percent. Three-phase units shall be four-wire, wye-connected and capable of supporting 100 percent unbalanced load.
- 3) Direct-Current Power Supplies:
 - a) Except for power supply units which form an integral part of an individual piece of equipment, all power supply and conditioning equipment shall comply with UL 1012 and shall be approved by UL, CSA, or FM for the application. All power supply equipment shall be provided in redundant configurations such that failure of a single unit will not disable all or any part of the instrumentation and communication systems. Provide DIN rail mount dual power supplies with DIN rail mount automatic switching power supply redundancy manager between power supplies. The power supply negative output terminal shall be grounded.
 - b) Furnish as required to power instruments and control circuits requiring dc power, including two-wire transmitters, relays, PROFIBUS panels, PROFIBUS instruments, PROFIBUS networks, and internal panel control devices.
 - (1) Supplier shall provide sizing calculations for each power supply in submittals.
 - c) Convert 120V ac, 60 Hz power to dc power of appropriate voltage(s) with sufficient voltage

regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.

- d) Provide output over voltage and over current protective devices to:
 - (1) Protect instruments from damage due to power supply failure.
 - (2) Protect power supply from damage due to external failure.
- e) Enclosures: NEMA 1.
- f) Mount such that dissipated heat does not adversely affect other components.
- g) Fuses: For each dc supply line to each individual two-wire transmitter.
- h) Type: Indicating.
- i) Mount so fuses can be easily seen and replaced
- j) Nominal 24-volt Direct-current Instrumentation and Control Power Supply:
 - (1) Convection-cooled linear type or switching type.
 - (2) Line Regulation: 0.4 percent for line variations from 105 volts to 132 volts.
 - (3) Load Regulation: 0.4 percent for load variations from 0 to full load.
 - (4) Ripple and Noise: Not exceed 100 mV peak-to-peak.
 - (5) Hold-up Time at Maximum Load: Not less than 16 milliseconds.
 - (6) Continuous duty from 0 degree C to 50 degrees C at rated load.
 - (7) Output electronically current limited.
 - (8) Over-voltage crowbar shutdown.
 - (9) Output Voltage:
 - (a) Rated 28V dc.
 - (b) Adjustable plus or minus 5 percent.
 - (c) Set to provide 26.4 volts to the panel direct current bus.
 - (10) Provide dry contact for failure alarm. Dry contact to be wired as input to PCS.
- s. Surge Protection:
 - 1) Provide primary surge protectors, per NEC Article 800.90 on all signal conductors entering the panel. Surge protectors shall be multi-stage, plug-in type selected to protect the equipment, and listed per ANSI/UL 497. Surge protectors shall be removable without changing the impedance of the circuit.

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

- B. Functional Characteristics: None.
- C. Performance Characteristics: None.

2.06 SUPPLIER PACKAGE SYSTEM SOFTWARE INTEGRATION

- A. Physical Characteristics: None.
- B. Functional Characteristics:
 - 1. The Supplier shall:
 - a. Provide detail PLC logic and controls to automatically operate all package system equipment.
 - b. Provide a package system PLC and HMI that shall interface to, and be integrated with, the PCS for supervisory control set points, command initiating points, monitoring and alarming as defined in the specific Supplier Equipment Specification, and programming requirements of Section 40 90 00, Instrumentation and Control for Process Systems.
- C. Performance Characteristics: None.

2.07 OUTDOOR PANEL SHADE COVERS

- A. Physical Characteristics: Fabricate custom-aluminum panel shade covers.
- B. Functional Characteristics: None.
- C. Performance Characteristics: None.

2.08 SAFETY ENCLOSURES AND MEASURES

- A. Physical Characteristics: Equipment shall have adequate removable enclosures to protect personnel against accidental contact with moving parts and prevent dripping in multilevel installations in accordance with the guards and caution sign requirements in Division 01, General Requirements.
- B. Functional Characteristics: None.
- C. Performance Characteristics: None.

2.09 ANCHOR BOLTS

- A. Physical Characteristics: Furnish all anchor bolts of ample size and strength required to securely anchor each item of equipment in accordance with Section 01 88 15, Anchorage and Bracing.
- B. Functional Characteristics: None.
- C. Performance Characteristics: None.

2.10 COATINGS

- A. Physical Characteristics: Coatings shall be provided in accordance with Section 09 90 00, Painting and Coating.
- B. Functional Characteristics: None.
- C. Performance Characteristics: None.

2.11 SPARE PARTS

- A. Physical Characteristics:

- 1. The following spare parts and special tools shall be provided in accordance with Division 01, General Requirements.

Spare Parts	Quantity
Indicators	Ten of each type of indicator used in the panels
Fuses	Five each of each type and rating of fuse used in the panels
Surge suppressors	One each of each type primary protector surge suppressor used in the panels
Surge protector	One each of each type of surge protective device used in the panels
HMI	One of each type for each package system
I/O Modules	10 percent, minimum one of each type used, for each panel
PLC Power Supplies	10 percent, minimum one of each type used, for each panel
PLC Processor	One of each type used
PLC Communications Module	One of each type used
Ethernet Switch	One of each type used

Spare Parts	Quantity
Panel Power Supplies	One of each type used
Transformer	One of each type used

2. One set of any special tools required to perform operation and maintenance activities and perform installation.

B. Functional Characteristics: None.

C. Performance Characteristics: None.

2.12 CONTROL REQUIREMENTS

A. Physical Characteristics: None.

B. Functional Characteristics:

1. Systems Integration:
 - a. Each package control system shall include manual and automatic control of all included package system process equipment. Each package control system shall be integrated (bidirectional data exchange) with the PCS over an Ethernet network interface.
 - b. The integration between the PCS and package control systems shall allow an operator working within the PCS full access to all data within the package control system and to view and modify (security protected function) all package system I/O points and application programs.
2. Power Failure Restart: The Package control system shall provide a fully automatic and sequenced restart of the package system equipment. The Supplier package system equipment shall only restart when directed by the PCS plant shutdown and restart control strategy, following a plant shutdown or loss of utility power. The programmed restart sequence and process variable feedback for the package system equipment shall wholly reside within the package control system and upon receipt of the restart command from PCS it shall automatically initiate a package system restart in an orderly sequence without causing any disruption to other Treatment Plant processes.

C. Performance Characteristics: None.

2.13 INSTRUMENT AIR

A. Physical Characteristics: Instrument air required to operate package systems pneumatic valves and instrumentation shall be provided by the Contractor and

will not be provided by the plant-wide instrument air distribution system, unless otherwise specified in the package system equipment specification.

- B. Functional Characteristics: None.
- C. Performance Characteristics: None.

2.14 FIELD INSTRUMENTATION

- A. Physical Characteristics:
 - 1. Field instrumentation shall be provided to measure and control the package systems process equipment. All instrumentation shall be in compliance with Division 40, Process Interconnections, requirements.
 - 2. Field instrumentation shall be selected and calibrated as defined by the process parameters and shall operate in the 40 percent to 60 percent range during normal process conditions.
 - 3. All analog process field instrumentation supplied with the Supplier package system shall use HART 4 mA to 20 mA instrumentation.
- B. Functional Characteristics: None.
- C. Performance Characteristics: None.

2.15 CONTROL VALVES

- A. Physical Characteristics: Control valve actuators supplied as part of the Supplier package system shall be in compliance with Section 40 27 02 Process Valves and Operators.
- B. Functional Characteristics: None.
- C. Performance Characteristics: None.

PART 3 EXECUTION

3.01 SHIPMENT AND STORAGE

- A. Equipment shall be shipped and stored in accordance with Section 01 67 00, Product Requirements.
- B. Supplier shall provide Contractor with detailed recommendations and instructions for equipment storage.

C. Control Panel Drawings:

1. Provide each panel with complete set of as-shipped approved submittal drawings, including all wiring diagrams, in a door mounted holder inside the control panel enclosure.
2. Provide each panel with a complete set of approved As-Built drawings, including all wiring diagrams, to replace the approved as-shipped drawings.

3.02 SUPPLIERS FIELD SERVICES

A. Supplier shall provide field services in accordance with Division 01, General Requirements, and as further required within this section.

1. For this Part 3, Supplier shall be inclusive of the Division 40, Process Interconnections, Package System Supplier.

B. Supplier shall provide assistance during equipment installation as required by the Contractor.

C. The equipment provided under this section shall be started and tested only under the direction of personnel provided by the Supplier.

D. In addition to the minimum onsite time necessary to complete the requirements established elsewhere within these specifications, package system supplier shall provide qualified individuals to perform the following during construction and testing:

1. Direct work during unloading of control system equipment and components onsite. This shall include attendance at a 1-day predelivery Site meeting with the Contracting Officer's Representative.
2. Attend Contractor and Contracting Officer meetings.
3. Program, install, test, start up, and commission the Supplier package control system.
4. Supplier's programming manager shall attend:
 - a. One-day (8-hour) Site meeting with the Contractor and the Contracting Officer prior to package system start-up.
 - b. Two-day (16-hour) review of the package control system's actual performance and operation 270 days after the package system has been formally accepted by the Contracting Officer to identify and correct any problems and make modifications to fully optimize the package system performance, prior to the expiration of the warranty period specified herein. Service time spent remedying control system equipment deficiencies/problems shall not be chargeable toward this review period.

E. Onsite services do not include travel time to and from the Work Site

- F. If the required minimum supplier trips and durations are insufficient in the opinion of the Contractor, the Contractor shall indicate the required amount and provided this information in the submittal.
- G. Provide a minimum of 40 hours telephone support for a period of 1 year following formal acceptance of the package control system by the Contracting Officer's Representative.

3.03 INSTALLATION

- A. Supplier's services shall be provided as specified in Section 01 67 00, Product Requirements.
- B. The Supplier shall provide the Contractor with detailed recommendations and instructions for installation of the equipment specified in this section.
- C. Supplier shall provide assistance during equipment installation as required by the Contractor.
- D. The equipment shall be aligned, connected, and installed at the locations shown and in accordance with the recommendations of the Supplier.
- E. Following installation, Supplier shall provide Certificate of Proper Installation, in accordance with Section 01 67 00, Product Requirements.
- F. The Contractor shall coordinate with the Supplier's onsite installation supervisor. The Supplier supervisor shall furnish technical direction for onsite labor associated with installation of the supplied equipment, landing of wiring/cabling, power wiring, grounding, field I/O wiring, and network cables for the package control system equipment. Contractor shall install the control system in accordance with Supplier's instructions and recommendations.
- G. The Supplier shall inspect the control system installation including I/O subsystems, data communications systems, hardware configuration, and all addressing and switch/jumper settings, and shall approve and certify the completed installation meets the Supplier's package control system requirements. Contractor shall make whatever modifications are required to achieve the Supplier's approval and certification of a complete installation.
- H. The Supplier shall monitor all system diagnostic indicators, both hardware and software, and certify that the system performance meets or exceeds the Supplier's published specifications for the package system provided.
- I. All installation fault or trouble conditions shall be investigated, documented, and resolved by the Contractor to the satisfaction of the Contracting Officer's Representative.

3.04 FIELD TESTING AND COMMISSIONING

- A. Field Testing and Commissioning shall be in accordance with the requirements of Section 01 91 14, Equipment Testing and Facility Startup.
- B. The Supplier shall provide detailed procedures for Field Testing and Commissioning procedures for the equipment specified in this section.
- C. Field Testing and Commissioning shall be performed under the direction of personnel provided by the Supplier.
- D. Following successful Field Testing and Commissioning, Supplier shall provide Certificate of Proper Field Testing and Commissioning.
- E. In addition to the Field Testing and Commissioning requirements specified in Section 01 91 14, Equipment Testing and Facility Startup, the following specific testing shall be performed. Plan, provide, and execute all Functional and Performance Tests of the complete control system including software functions to support startup of plant.
 - 1. Component Installation Test: Components, Instruments, and Panels
 - 2. Component Operational Readiness Test: Systems, Controls, HMI and PLC functions local to the Supplier package system
 - 3. Functional Tests: System, Controls, HMI and PLC functions, and PLC to/from PCS functions.
 - 4. Pre-Startup Tests: Prior to facility startup, inspect, test, and document that the control system is ready for operation.
 - 5. Start-up Tests: Test all components and systems to perform all functions for plant operations.
 - 6. Acceptance Tests: Tests to confirm the system is performing as per the requirements of each equipment specification.
- F. Component Installation Test:
 - 1. Verify instruments, panels, and components for proper installation, calibration, and adjustment, on a loop-by-loop and component-by-component basis. Document results on loop test status reports, instrument calibration sheets, test forms, and check lists.
 - 2. Provide certification of proper installation has been issued,
- G. Component Operational Readiness Test:
 - 1. Supplier shall coordinate with the Contractor and the Contracting Officer to perform components, instruments, and panel testing of the Suppliers entire package control system. Testing procedures shall be submitted in writing, conform to testing requirements in this section,

and be conducted in conjunction with the preliminary testing of the process equipment.

- a. Verify instruments, panels, and components for proper connectivity, power, and functionality as a standalone component.
 - b. Test each, and every, PCS interface by simulating the PCS signals and testing the expected functions of the Suppliers system.
 - c. Test each, and every interlock, for complete functionality from the source device to the control system.
 - d. Test each, and every PLC I/O, and control functions.
 - e. Test each, and every alarm.
 - f. Test each, and every, PCS interface by simulating the PCS signals and testing the expected functions of the Suppliers system.
2. Document results on loop test status reports, instrument calibration sheets, test forms, and check lists. Perform operational readiness tests including software functions and data communications for all control, monitoring and alarm loops and document test results on test procedure forms.
 3. Supplier shall complete all control system component testing to the satisfaction of the Contracting Officer's Representative, and accepted by the Contracting Officer's Representative, prior to commencing any Functional testing.

H. Functional Test:

1. Following completion of component tests including correction of any deficiencies or problems discovered, the Contractor and the Contracting Officer shall conduct the functional tests of all controls including PLC, HMI, and PLC to/from PCS. The Supplier shall submit the Functional testing procedures as specified in this section and Division 01, General Requirements.
2. Supplier to test the Suppliers entire package system, including interfaces to other systems that interact with the Suppliers package system. Test for functionality between the Suppliers equipment and package control system with the PCS and the other systems. Test each, and every, PCS interface with the Suppliers package system for the expected functions of the Suppliers system, including the interface to other systems through the PCS. Document results on loop test status reports. Perform functional tests including software functions and data communications for all control, monitoring and alarm loops and document test results on test procedure forms. Provide onsite testing and startup time devoted to data exchange testing, message validation and network timing validation with PCS.
3. Notice of satisfactory completion of the system test shall be issued upon acceptance and approval of the Contracting Officer's Representative.

I. Pre-Startup Test Phase:

1. After completion of all functional tests, provide the services of an experienced and skilled instrument and PLC/HMI technicians to support the PCS Supplier for the Pre-Startup testing.
2. Test an entire facility, or multiple integrated systems, in normal operational sequence including inter-process controls and inter-process interlocks. This phase shall test the integrated system controls and operations through normal operating ranges. The test shall include all PCS controls, all PCS interlocks, all inter-process interlocks, and all operations interfaces across these multiple integrated systems. The controls are as defined in Section 40 90 00, Instrumentation and Control for Process Systems. Inter-process interlocks are identified within the Control Descriptions. Preliminary facility operational training shall continue during the Pre-Startup Test Phase and shall be completed by the end of the Startup Test Phase. Temporary connections to utility water shall be provided for the source of testing medium with adequate temporary connections for discharge, or recycle, of the testing medium.

J. Startup Test Phase:

1. After completion of Pre-Startup Testing, provide the services of an experienced instrument and PLC/HMI technicians to support the PCS Supplier, Contracting Officer, and Contractor during Startup Testing.
2. Entire facility equipment and operations tested similar to the Pre-Startup Test except with the specified process medium. Perform all Pre-Performance (if applicable) and Performance Testing. Tests shall be executed on all components, systems, and facility and shall include all the Performance tests as specified in the individual equipment technical specification sections. Final operational training shall start upon completion of the Pre-Startup Test Phase and completed by the end of the Startup Test Phase.

K. Acceptance and Optimization Test Phases:

1. After completion of Startup Testing, provided the services of an experienced instrument and PLC/HMI technicians to support the Suppliers Performance Testing, and Optimization Testing of the Suppliers system. Provide the services of a qualified technician on call around the clock (24 hours per day), to assist the Contracting Officer's Representative during Supplier Performance and Optimization testing.
2. Acceptance Test Phase: A final test of all systems operating together on specified media to demonstrate satisfactory performance of the new and existing facility as a whole, without significant failure, and as specified, for the approval by the Contracting Officer.

3. Optimization Testing: Optimization Testing is intended to provide System Supplier's services to optimize specific systems, as specified in equipment specifications, to optimize the operation for that specific system at the Contracting Officer's discretion. Optimization Testing does not impact Performance Testing and shall only be performed after Performance Testing has been successfully completed. Perform all equipment Optimization Testing as per requirements in equipment specifications.

3.05 TRAINING

- A. Training shall be provided as specified in Section 01 78 23, Operations and Maintenance Data.
- B. A minimum of 20 Package System Supplier hours of total training shall be provided. The training shall be comprised of the following:
 1. Operations Training: Two sessions, 3 hours per session.
 2. Maintenance Training: Two sessions, 3 hours per session.
 - a. Provide training for all package components including panels, panel devices, instruments.
 3. PLC Program Training: Two sessions, 4 hours per session.
 - a. Provide training on the final PLC applications software program and its function, organization, and content.
- C. Upon completion of the training activities, the Supplier shall provide a Certification of Training Completion.

3.06 ASSEMBLY

- A. The equipment specified herein shall be factory assembled. The parts and assemblies that are of necessity shipped unassembled shall be packaged and tagged in a manner that will protect the equipment from damage and provide easy identification to facilitate the final assembly in the field. All hardware items shall be shipped to the Job Site in a timely manner, to meet the established construction schedule. The package control system equipment and instrumentation shall adhere to the shipping and storage requirements of this section.
- B. Components shall be tagged per the correct designations including terminal blocks, termination units, power supplies, cables and wiring, and instruments required to make a complete operational control system as specified herein.

END OF SECTION