

SECTION 16940
INSTRUMENTATION AND FIELD DEVICES

PART 1 - GENERAL

1.1 SCOPE OF WORK

- A. Provide all devices, wiring, terminal blocks, accessories, and enclosures as specified herein and as shown on Contract Drawings for the instrumentation system. The Contract Documents are intended as an outline for the work and are descriptive of the type of hardware and software configuration to be provided. Any error or omission of detail shall not relieve the Contractor from the obligations hereunder to provide and install in correct detail any and all materials necessary for a complete operational instrumentation system, at no additional cost to the State.
- B. The major areas in the scope of work which includes both the furnishing and installation are:
 - 1. Provide/install instrumentation system as shown and specified herein and in Division 16.
 - 2. Instrumentation devices such as level elements (LE), pressure indicators (PI), pressure indicating transmitters (PIT), flow elements (FE), may not be shown on Mechanical Drawings. All instrumentation devices shall be provided and installed by the Contractor at the locations in the process as shown on the Contract Drawings. It is the Contractor's responsibility to install all new and relocated instruments per manufacturer's installation requirements even if not specifically shown on the Contract Drawings.
 - 3. All necessary piping and valves to have complete installation.
- C. The Contract Documents are not intended to cover every detail of materials, software, hardware, configuration, or construction. The Contractor shall furnish all tools, temporary utilities, materials, setup, parts, labor, and other incidentals necessary to fully complete the entire work, whether or not said details are particularly shown or specified, all at no additional cost to the State.
- D. Ranges for instruments shall be as shown on in Appendix B or C Instrumentation and Field Devices Index or as marked-up during Submittal. Process setpoints will be provided by State during Submittal process, testing, and startup.
- E. All equipment, hardware, and software shall be licensed to the State.
- F. All necessary miscellaneous shut off, sample, and calibration valves to sensors.

Section 16940 – Page 2
Instrumentation and Field Devices

- G. Provide all necessary hardware, conduit, wiring, fittings, and devices to connect the electrical equipment provided under other Sections. The following shall be done by the Contractor at no additional cost to the State:
 - 1. Provide additional devices, wiring, conduits, relays, isolators to complete interfaces of the electrical and instrumentation system.
 - 2. Changing normally open contacts to normally closed contacts or vice versa.
 - 3. Adding additional relays to provide more contacts as necessary.

1.2 SUBMITTALS

- A. Manufacturer's literature and installation recommendations for all instrumentation provided.
- B. Schematic (elementary or ladder) diagram and wiring (interconnection) diagram for each control system.
- C. All drawings shall be drawn using AutoCAD, drawn in a professional manner and submitted on 11" x 17" sheets. Shop drawings shall be provided with minimum drafting details as illustrated on the Contract "electrical" series drawings. Diagrams shall carry a uniform and coordinated set of wire colors, wire numbers, and terminal block numbers. The shop drawings shall include:
 - 1. Electrical one-line diagrams detailing all devices associated with the power distribution system. The following applicable information or data shall be shown on the one-line diagram: location, size and amperage rating of bus; size and amperage rating of wire or cable; breaker ratings, number of poles, and frame sizes; generator receptacle; manual transfer switch, utility metering, voltage, amperage, number of wires and phases; fault interrupt ratings; ground size and connections; neutral size and connections; power fail and other protective devices; fuse size and type; distribution transformer; panelboard; starters; contactor size and overload range; motor full load amperage of submitted motor and horsepower; rating for miscellaneous loads; etc. Submit a list for each piece of equipment containing the motor voltage, phase and full load amps with one-lines for verification of accuracy of submitted one line drawings.
 - 2. Elementary diagrams shall be provided for all relay logic, power supplies, PLC I/O and other wiring. All elementary diagrams shall be drawn in JIC EMP/EGP format and standards similar to those shown on the E-series elementary diagrams showing ladder rung numbers and coil & contact cross referencing numbers.

3. Analog and digital I/O loop diagrams shall be provided showing the wiring requirements for each instrument loop. Graphic symbols shall conform with ISA S5.4 drawing standards. A loop diagram shall be furnished for each analog and digital I/O process and all PLC I/O cards. Loop diagrams shall include the following as a minimum:
 - a. The loop diagram shall be drawn with sufficient detail to express control philosophy. The diagram shall show all components and accessories of the instrument loop, highlighting special safety and other requirements. These diagrams shall be arranged to emphasize device elements and their functions as an aid to understanding the operation of a system and for maintaining or troubleshooting that system.
 - b. A separate drawing shall be prepared for each analog and digital card. Each card shall be arranged on the diagram in the same order as the physical arrangement of the card terminations. All termination points on the diagram shall be shown with the actual equipment identification, device and relay terminal number or letter, and I/O point P&ID English descriptor and tag name. A separate drawing shall be prepared for each card.
 - c. Energy sources - electrical power, air supply, pneumatic and hydraulic fluid supply, designating voltage, current, pressure, etc. shall be shown in detail on the diagram. Input and output signals (e.g., 1-5 VDC, 4-20 mA DC, 3-15 psig, etc.), power and instrument supplies to devices (e.g. 120 VAC, 24 VDC, 80 psig, etc.) shall be shown.
 - d. Engineering units shall be shown on the diagram. Each wire label, equipment identification terminal number or letter and color code shall be shown. Signal and DC polarities shall be shown.
 - e. All spare wires, cables and termination points shall be shown. All jumpers, grounding, shielding, power supply details shall be shown.
4. Enclosure and Elevation layout diagrams for Electrical Panels/Pedestal; show all front panel, sidepan and backpan devices drawn to scale. Show fabrication methods and details; including material of construction, paint color, support & latching mechanisms, fans & ventilation system, and conduit entrance areas.

Section 16940 – Page 4
Instrumentation and Field Devices

5. Interconnection Diagram - An interconnection diagram shall be furnished for each electrical and instrumentation system. Each interconnection diagram shall include the following as a minimum:
 - a. The diagrams shall be utilized by the electrician during all phases installation and connection of all conductors to ensure coordination of equipment interconnect.
 - b. The diagrams shall show wiring as field labeled.
 - c. Interconnections shall be shown point to point with identified lines. Diagrams of the wireless or wire schedule type are not acceptable. Bundled wires shall be shown as a single line with the direction of entry/exit of individual wires clearly shown. Interconnect diagrams shall not be combined with loop or elementary diagrams.
 - d. All terminations points on the diagram shall be shown with the actual equipment identification terminal number or letter. This identification of terminations includes terminal blocks, junction boxes, all devices, computer I/O points, etc.
 - e. Diagrams shall include raceway numbers, raceway size, cable numbers, wire color code, and wire numbers.
 - f. Each wire and cable size and color code shall be shown. Each conduit route with the conduit label and conduit size shall be shown. Wire and cable routing through conduits, wireways, manholes, handholes, junction boxes, terminal boxes and other electrical enclosures shall be shown with the appropriate equipment labels. All spare wires, cable, and termination points shall be shown. Cable shields shall be shown.
 - g. Labeling codes for terminal blocks, terminals, wires, cables, panels, cabinets, instruments, devices, and equipment shall be shown.
 - h. Schematic symbols shall be used for field devices, showing electrical contacts. Signal and DC circuit polarities shall be shown.
 - i. The diagrams shall show all other Contract and supplier drawing numbers, for reference, that are associated with each device that is interconnected.
 - j. Field wiring shall not start before the interconnection drawing have been submitted by the Contractor and approved by the State representative.

- k. Do not show the same wires or jumpers on the elementary or loop and interconnection diagrams. All jumpers, shielding, and grounding termination details not shown on the connection diagrams shall be shown on the interconnection diagrams.
- l. Interconnection diagrams shall be submitted and approved by State representative for each electrical and instrumentation system. The Contractor shall not pull in any wires into conduits that does not have approved interconnects. If the Contractor pulls in wire without State representative approval of associated interconnect drawings, the Contractor will not be reimbursed for labor for re-pulling in wires even if there was an error in wire fill or sizing. Also, if the Contractor pulls in wire without State representative approval of associated interconnect drawings, then all progress payments for that particular area of work will be withheld until approved interconnect drawings are in use.
- m. The diagrams shall show all other Contract and Supplier drawing numbers, for reference, that are associated with each device that is interconnected. Attached with each interconnect, a copy of all the support documents used in preparing interconnects. This includes current issues of panel schematics, connection diagrams, terminal block diagrams, submittals, contract drawings, vendor drawings and all other data used to develop the interconnection diagram as noted in the "Reference Documents" corner of interconnect drawings.
- n. All interconnection diagrams shall be prepared and checked by a California Registered Electrical Engineer and shall bear that Engineer's professional stamp and signature on each and every interconnect drawing submitted for approval and on as-built interconnect drawings. All deletions and additions of equipment, wire and cables shall be clearly shown. Interconnects shall include list of all applicable reference drawings, request for clarifications, field instructions and change orders.
- o. Provide a notes section on each interconnect drawing. In the note section, provide a detailed list of any variances from the Contract conduit schedule necessary for completing the interconnections (i.e. wire fill changes, conduit additions, etc). Change orders regarding wire fill, conduit schedule and errors in plans regarding conduits and wires may not be processed until interconnect drawings have been received for such work.

Section 16940 – Page 6
Instrumentation and Field Devices

- p. The field electrician shall mark-up all interconnection diagrams during installation to show accurate as-built wiring, conduits runs, terminations, etc.
- 6. Submit full size drawing of all nameplates and tags, as specified herein, to be used on project. The State's Representative has the right to adjust nameplate engraving titles during submittals at no additional cost to the State representative. Submittal to include the following:
 - a. Dimensions of nameplate.
 - b. Exact lettering and font for each nameplate.
 - c. Color of nameplate.
 - d. Color of lettering.
 - e. Materials of construction.
 - f. Method and materials for attachment.
 - g. Drawing showing location of nameplate on each panel.
- D. Provide the following three separate processor programmable controller (PLC) applications programming software and SCADA graphics submittals for each processor program:
 - 1. Preliminary Submittal – PLC & SCADA hardware and software configuration shall be submitted at 10 percent complete level for a preliminary courtesy check by the Contracting Officer or State's Representative. This check will not entail a detailed check of all performance features and will not absolve the Contractor of his Contract responsibilities. It is required that the PLC & SCADA applications software be fully annotated with complete description of control logic, explanation of symbology, and convention including legend list.
 - 2. Formal Submittal - This is the submittal for review per Contract Requirements and is to be submitted after approval by Contracting Officer or State's Representative of the preliminary submittal. This submittal shall be approved for basic content (not for correctness of ladder logic code) by Contracting Officer or State's Representative prior to start of any PLC & SCADA factory tests.
 - 3. Final Submittal - This submittal will be part of O & M manual. The software documentation shall be the as-finished records of the formal submittal and other documents used during testing and startup. Three (3) weeks (minimum) prior to the start of the factory tests, the Contractor shall submit for approval the following software information:

- E. Three (3) weeks (minimum) prior to the start of the factory tests, the Contractor shall submit for approval the following software information:
1. Submit PLC software submittal showing the structure of the applications programs and the purpose of each module.
 - a. English description, flowchart, and index of each major ladder logic program section illustrating subsection of program organization.
 - b. Include high level block diagram and English description of PLC file structure.
 - c. Include comments for each block of code explaining purpose of individual lines.
 - d. Include a listing of all setpoints with their corresponding English description.
 - e. Manual shall include complete explanation on the set-up and configuration of the PLC hardware and software.
 - f. Include a description of the PLC diagnostic and Ladder Logic programming functions available through the diagnostic computer.
 2. PLC software submittal documentation shall include machine printed ladder diagrams and listings. This documentation shall detail the following:
 - a. The ladder diagrams shall be drawn with the contacts on the left side of the coil on each rung. Each contact and coil shall have a typed description of its function. A line-by-line typewritten description of the each rung shall be given on the ladder diagrams. Each I/O point in the ladder logic shall be shown with it's corresponding I/O "tagname"; i.e. Y1001 for digital input of Disk Filter Isolation Weir Gate Remote/Local switch.
 - b. An "Input/Output List," tabulating the module location, terminal points, channel number, address number, point type, point voltage, input/output designation "nickname" and/or number, and a textual description for each item of input and output.
 - c. A "Constant Memory Assignment List," tabulating the assigned register name, location number, and textual description for each constant stored in memory.
 - d. A "Variable Memory Assignment List," tabulating the assigned register name, location number, and textual description for each variable stored in memory.

Section 16940 – Page 8
Instrumentation and Field Devices

- e. A "Cross Reference List," tabulating the rung locations for the usage of each symbol throughout the ladder logic. For each coil, the rung locations for each of its contacts shall be listed. For each input all the rungs in the ladder logic in which it is used shall be listed.
 - f. A "Memory Map and Usage List," tabulating the allocation of CPU memory. This listing shall identify the contents of the reserved memory and what areas are unused.
 - g. A brief description on a page preceding the ladder diagram listings, describing all symbols and functions used on the ladder diagram.
 - h. A written description of lookup table data, for each lookup table. Include the source of data used for each table.
 - i. A brief description, on each page of "Special Function" listings, including:
 - 1) A textual description of input variables and/or constants.
 - 2) A textual description of output variables and/or constants.
 - 3) A textual description of the functions.
 - 4) Reference(s) to any specific locations on the ladder diagram listings where the special functions apply.
3. Submittal content shall comply with the following:
- a. Contain complete and separate data files shall be provided for each PLC applications program.
 - b. Applications program files shall be capable of being uploaded from the PLC and separate comment files shall be capable of being merged with the code for program maintenance.
 - c. Program files shall be stored in a format that can be retrieved, edited, merged with comment files, and downloaded to PLC using the programming software.
 - d. Listing of all setpoints with proposed initial numeric entry values and corresponding Engineering Units for control strategies. Submit spreadsheet style setpoint list for all pressure, flow, level, timers, etc.
 - e. Listing of all digital and analog registers, bits, timers etc., their respective description, I/O tagnames, and full addresses for development of factory test screen.

- f. Complete commented ladder logic program.
 - g. Map all analog and digital inputs/outputs including spares to B, F, or N registers.
 - h. Transfer all data between PLCs, SLCs, and Chem Scan units for a complete and operable system.
 - 4. Submittal of color printout of all SCADA graphic screens proposed and their associated database.
 - 5. Submit software documentation demonstrating understanding of control software requirements.
 - 6. The Contractor shall submit for approval the resume of the application programmer listing all relevant experience. Application programmer that does not have relevant experience to this project will be rejected by Contracting Officer or State's Representative and the Contractor shall submit the resume of a qualified application programmer.
- F. Submittals shall be placed in three ring binders with complete index of contents and all drawings (place in front of other submittal material). All copies shall be clear and legible. Data sheets shall be provided for each instrument with an index and proper identification and cross-referencing. Each drawing title block shall contain the English description name for drawing contents (i.e. Lift Pump No. 1 Interconnect Drawing) and drawing number. All pages and drawings in the submittal shall be numbered sequentially (with no number skipped) in lower right hand corner. PLC Data files shall be provided with an index and proper identification and cross-referencing.
- G. Exceptions to the Contract specifications, control strategies or drawings shall be clearly defined by the equipment supplier. Data shall contain sufficient details so a proper evaluation may be made by the State's Representative. Request for information (RFIs) shall not be included in submittals. RFI's shall be submitted separately in its individual submittal number.
- H. The Supplier shall coordinate submittals (including software submittals) with the work so that project will not be delayed. This coordination shall include scheduling the different categories of submittals, so that one will not be delayed for lack of coordination with another.
- I. No material, equipment, or software shall be allowed at the job site until the submittal for such items has been favorably reviewed by the State's Representative and marked "No Exceptions Taken" or "Make Corrections Noted".

Section 16940 – Page 10
Instrumentation and Field Devices

- J. The equipment specifications have prepared on the basis of the equipment first named in the Specifications. The Supplier shall note that the second named equipment, if given, is considered acceptable and equal equipment, but in some cases additional design, options, or modifications may be required, at no additional cost, to meet Specifications.
- K. The decision of the State's Representative governs what is acceptable as a substitution. If the State's Representative considers it necessary, tests to determine equality of the proposed substitution shall be made, at the Supplier's expense, by an unbiased laboratory satisfactory to the State's Representative.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data for review and approval.
 - 1. Manufacturer's operation and maintenance data for instrumentation.

1.4 QUALITY ASSURANCE

- A. Worker's Qualifications: All electrical work shall be performed by licensed electricians or under the direct supervision of a licensed electrician.
- B. A quality assurance procedure shall be defined and implemented by the Contractor or subcontractor supervising instrumentation and control systems. The procedure shall:
 - 1. Require that the project manager schedule and budget for in-house and inter-Contractor checking.
 - a. Specify qualifications required for engineering and technical personnel in the execution and checking of specific tasks.
 - b. Identify the responsibilities of the executor and the checker.
 - c. Provide quality assurance data sheets listing specific tasks and stages of tasks, with space for the printed names of the executor and checker, and the checker's signature and date.
 - 2. The quality assurance procedure shall form part of the contractual requirements for subcontractors, and manufacturers or suppliers with unit responsibility. Quality assurance data sheets shall be submitted to State on a weekly basis. Failure of Contractor to provide quality assurance data sheets in a timely manner will stop all progress payment for Instrumentation work.

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM

- A. Control Panel located shall consist of the relay system, and other devices for a complete and operational system.

2.2 APPLICATIONS PROGRAM

- A. PLC & SCADA Software Configuration: The Supplier shall provide the PLC & SCADA completely configured and programmed for the monitoring and control of the process. The PLC & SCADA shall be setup as defined herein. The PLC & SCADA shall be ready to be placed in operation at the time of factory test. The programming, setup and configuration of the PLC & SCADA shall be done by the PLC & SCADA supplier. All programming shall be performed by an application programmer with prior experience on similar PLC & SCADA projects. The State reserves the right to judge if the application programmer assigned to this project is adequate for the task. If the programming performed is deemed inadequate by the State's representative, then the supplier shall provide a qualified application programmer to meet these requirements.
- B. The setup details given for the PLC & SCADA are intended as guidelines for the supplier to use to configure the system. The setup details were prepared with the available information on the software package and may not be the best way to accomplish the task. Errors and omissions in these details shall be the supplier's responsibility to correct, at no additional cost to State. The supplier shall meet the intent of the setup specified, making modifications as necessary to provide an operational system, at no additional cost to the State.

2.3 MISCELLANEOUS DEVICES

- A. Provide terminal blocks, fuses, nameplates, pushbuttons, selector switches, indicating lights, relays and timers as specified in other Sections of Division 16.
- B. DC Power Supplies:
 - 1. The DC power supply shall use a "linear" type power conversion. "Switching" type power supplies are not acceptable. The 12 & 24 VDC power supplies shall be capable of providing a minimum amperage as shown on Contract Drawings and not over 50% loaded. Submit load calculations of all connected 12VDC & 24VDC loads showing power supplies are adequately sized.

Section 16940 – Page 12
Instrumentation and Field Devices

2. The AC input voltage step-down transformer shall have separate and isolated primary and secondary windings. This transformer shall provide a minimum of 3,000 V RMS isolation between the input & ground and input & output. The negative output of the power supply shall be grounded to chassis. Short circuit and overload protection shall be provided by electronic current limiting and foldback with automatic recovery. Automatic remote voltage sensing and adjustment shall be a standard off the shelf part of the power supply. A manual output voltage adjustment potentiometer shall be provided on each power supply.
 3. All power supplies shall be U.L. recognized. Power supply shall be Power-One "International Series Linear", Sola, or approved equal.
- C. Each isolator shall provide complete isolation of the 4-20 mA output signal from the input signal and isolator power supply. Each isolator shall have all solid state circuitry mounted in a plug-in module. The 4-20 mA output signal shall be capable of driving a 600 ohm load. Accuracy shall be +/- 0.25% of span. The isolator shall be powered as shown on Contract Drawings. Each isolator shall have a seven year warranty. The isolators shall be as manufactured by AGM Electronics, Action Instruments, or approved equal.

2.4 ULTRASONIC LEVEL TRANSMITTER

- A. Each ultrasonic level indicating transmitter shall be a microprocessor based echo-time ultra-sonic type providing an electrical level output signal proportional to the measured level.
- B. Provide ultrasonic level elements with level indicating transmitters. Use the following models, or approved equal.
1. Level (Differential) Indicating Milltronics HydroRanger Transmitter (LIT or LDIT): 200, Danfoss Sonolev, or approved equal.
 2. Level Element (LE) Transducer: To match LIT.
- C. Provide Level indicating transmitter (LIT) / signal converters meeting the following requirements:
1. Power Supply: Per device index.
 2. Measurement Range: 1 to 33 feet.
 3. Discrete Outputs: 5 relay outputs-SPDT contacts rated 5A/250 VAC; keypad function programmable.
 4. Analog Output: Current-isolated 4 to 20mA into 1000 ohms max.

5. Displays: 100mm x 40mm multifield backlit LCD display.
 6. Communications: User interface via detachable infrared keypad programmer.
 7. Operating Temp.: -5° F to 122° F.
 8. Temp. Compensation: -58° F to 302° F.
 9. Resolution: The greater of +/- 0.1% of range or 0.08 inches.
 10. Accuracy: +/-0.25% or range.
 11. Memory: Non-volatile EEPROM, no battery required.
 12. Enclosure Rating: NEMA rated per Device Index.
- D. Provide Level element (LE) transducers meeting the following physical requirements:
1. Mounting: Support.
 2. Construction: Kynar.
 3. Sensor Material: Standard Construction.
 4. Temp. Compensation: Internal.
 5. Oper. Frequency: 43 KHz.
 6. Beam Angle: 12 degrees.
 7. Range: 1 to 33 feet maximum.
 8. Separation: 328 feet minimum between sensor and electronics without use of additional equipment.
- E. Each level element (LE) shall be supplied with sufficient cable length to reach the remote level/level indicating transmitter (LIT) without the use of splices. Any cable that is found to be spliced shall be removed and replaced by the Contractor, at no cost to the State.
- F. All programmable parameters shall be set up and entered by the System Supplier for Level measurement.

Section 16940 – Page 14
Instrumentation and Field Devices

2.5 DISSOLVED OXYGEN METER

- A. Acceptable dissolve oxygen (D.O.) meter manufacturers: Danfoss USC Signal Converter, OXY 2100 Transmitter, and OXY 4100 Sensor, or approved equal.
- B. Range: per Analytical Device Index.
- C. Operating temperature: 0 degrees F to +120 degrees F.
- D. D.O. sensor as follows:
 - 1. Gold cathode with silver anode and built-in RTD sensor.
 - 2. Accuracy: 0.5% (FSO).
- E. Enclosure: NEMA rated per Analytical Device Index with clear window for viewing D.O. concentrations.
- F. Signal converter shall provide the following:
 - 1. Display D.O. and temperature on three line LCD display with backlight.
 - 2. Two isolated 4 to 20 mA outputs for each input:
 - a. Proportional to D.O.
 - b. Temperature
- G. Three (3) D.O. alarms, with setpoints programmable across the entire operating range, and with programmable dead band relay for external use.
- H. Power: 115/230 VAC, 50/60 Hertz.
- I. Sensor:
 - 1. Remote sensor with 20 feet of cable for interconnection to the transmitter.
 - 2. Furnish and install mounting kit consisting of guardrail brackets and pipe adopter for mounting pipe to guard rails.
 - 3. Provide self-cleaning ball float with fins to keep sensor clean.

2.6 ETHERNET COMPONENTS

A. Ethernet Switches

1. Switches shall be provided for PLC system as shown on Contract Drawing SCADA block diagram. Ethernet switches shall have 8 ports (unless otherwise noted), 10/100 Base T. Ethernet switches shall be N-Tron 900-Series, Hirschmann RS2, or approved equal.

B. Wireless Access Point

1. Provide wireless access point Ethernet bridge with 5-port switch with encryption capabilities. Access points shall be Netgear, Z-Link or approved equal.

2.7 DATA FLOW SYSTEM

- A. Data Flow System shall be compatible with existing remote units and new SCADA Operator Interface. System supplier shall provide all necessary hardware, software, devices, connecting wires, etc for a complete and operable system. Data flow system shall be DFS (321 259-5009) HyperSCADA Server (HSS001) including internal modems, radio, 4 port network switch and power supply to replace existing system.

2.8 OPERATOR INTERFACE

- A. The Contractor shall completely assemble, install & setup OI hardware components and load all software except for SCADA software. Complete operator interfaces shall consist of the following:

1. Computer System.
2. SCADA software, Development System and Auxiliary Software.
3. Color Printer.

- B. Computer System: The operator interface computer shall comply with the following specifications. Any computer substituted as an equal may be subject to numerous bench-mark tests, software manufacturer's approval, and any other test deemed appropriate to prove equality, all at the Supplier's expense. Any expenses resulting from delay of progress due to a substituted computer's incompatibilities shall be borne by the Supplier. Provide a Dell XPS 210, Gateway, Micron PC, or equal meeting the following specifications:

1. Intel Pentium D Processor 915 - 4MB Processor at 2.8 GHz minimum.
2. 2 GB 667 MHz SDRAM.

Section 16940 – Page 16
Instrumentation and Field Devices

3. 160 GB Hard Drive (3.0 Gb/s), minimum.
 4. Integrated Graphics Card.
 5. Integrated sound card.
 6. 8X Recordable/ReWriteable IDE DVD-ROM Drive.
 7. Ultra Small Form Factor case
 8. One (1) serial port
 9. One (1) PCI slot.
 10. Nine (9) USB ports
 11. Speakers with Subwoofer.
 12. QuietKey Keyboard.
 13. MS IntelliMouse Optical, scroll, USB with mouse pad.
 14. 10/100 Fast Ethernet Card.
- C. Provide 15' length (minimum) of cables (power, communication, etc.) to computer station. All cables shall be provided with plugs/receptacle pull-apart connectors. Cables with connectors shall be provided for the following:
1. Ten (10) Ethernet Network Patch cables.
 2. PC Power Cable.
 3. Printer cable between computer and printer.
- D. MONITOR
1. The monitor shall be supplied with manufacturer's cable and tilt/swivel base.
 2. COLOR: The monitor shall have a flat screen, non-glare, color screen for maximum contrast and minimum glare. Display resolution shall be 1280 H x 1024 V pixels (minimum) for greater clarity and detail. The monitor shall support use of CGA, EGA, enhanced EGA, PGC, MCGA, VGA, SVGA video graphic controller boards. The monitor shall be 19-inch viewable (minimum) Flat Panel LCD, active matrix TFT with 0.30 mm (minimum) dot pitch.

E. Software

1. All software provided shall be Year 2000 and Microsoft XP compliant.
2. All software supplied shall run under Windows XP operating system.
3. WORKSTATION OPERATING SYSTEM: Provide Microsoft XP Professional operating system for each Operator Interface. Windows Vista is not acceptable.
4. SCADA Software:
 - a. One (1) each Wonderware FactorySuite Runtime 60K tag version 9.5 60K tag license, Intellution, RS View or later for Windows XP. SCADA software shall be supported by a registered/certified system supplier for the product within a 300 mile radius. System shall include the following:
 - 1) Wizards for developing template graphics
 - 2) Drop down symbols for developing graphics to represent P&IDs
 - 3) Graphical editing displays
 - 4) Scripting
 - 5) Multiple Alarms levels and built-in color changes per alarm status
 - 6) All I/O Drivers
 - b. Provide one set of Wonderware SCADAAlarm, Specter Instruments Win 911, Unified Control Messaging or Windows-based autodialer software, or approved equal, for Operator Interface. Software shall be compatible with SCADA software for callout on alarms. Autodialer shall have configurable unlimited phone callout list and unlimited alarm tagname dictionary, manual or automatic acknowledgment of alarms and provide configurable audible annunciation of analog values. Autodialer shall allow personalized voice greetings, recordable on site. Autodialer software shall be Windows XP compatible. An external voice modem compatible with the software shall be provided for alarm dial-out. Provide microphone and connecting wires between modem and PC for the speaker input.
 - c. Mouse Driver: The mouse driver software shall be completely and thoroughly compatible with the application software.

Section 16940 – Page 18
Instrumentation and Field Devices

- d. File Manager: Provide File manager that has a file compression feature.
- e. Auxiliary Software: Provide Anti-Virus software and Microsoft Office XP professional edition which includes programs Microsoft Excel, Word, PowerPoint, Outlook, Access and Bookshelf Basics, no equal.

F. Color Printer

1. Color printer shall be capable of printing 13 color /20 black pages per minute. Color printer shall have the following standard features:
 - a. The color printer shall be compatible with the SCADA software provided to allow an operator to obtain a hard copy of any color graphic screen or historical trend using the standard commands without any specialized procedures.
 - b. Panel push button control of power, and reset shall be provided.
 - c. Panel indicator LEDs for paper out and power shall be provided.
 - d. The printer shall be equipped to handle single cut-sheet, 8.5 x 11 inch, paper while sitting on a standard table top.
 - e. The printer shall be provided with rechargeable color and black cartridges compatible with printer.
 - f. A 8MB printer buffer shall be built-in the printer to buffer information. The print buffer shall buffer all printer information when the printer is off line or out of paper without loss of data.
 - g. Printer shall be compatible with latest version of Windows XP and network ready.
 - h. Provide three (3) sets of spare color/black cartridges.
 - i. The laser jet printer shall be a Dell Color Laser Printer 3110cn, HP, Lexmark or approved equal.

G. Power Conditioning

1. Provide Transient Surge Protection for the 120 VAC power line feed to the SCADA computer. Transient surge protection equipment shall meet the following specifications
 - a. Response Time: 5 nanoseconds, maximum.
 - b. Surge Current Test (ANSI C62.41): Category B, 3KA.

- c. Maximum Let Through Voltage (3 KA per ANSI C62.41): 340 Volts.
- d. Operating Voltage: 120 VAC, 60 Hz.
- e. Operating Current: 15 Amp Service.
- f. Connections: Brass Studs.
- g. Replaceable Fuse Indicator: Neon failure indicator.

2.9 PROGRAMMING AND CONTROL STRATEGIES

- A. Submit for approval the resume of the application programmer listing all similar PLC, Allen-Bradley & SCADA programming experience on water projects for the past five years. Programmer with inadequate prior experience as judged by State will not be allowed to do the PLC & SCADA programming for this project.
- B. No application programming will be allowed to be done at the jobsite prior to start-up testing. Contractor is responsible to have PLC programming & SCADA software as necessary for software submittals, tests, O&M documentation, and other associated tasks. The PLC ladder logic applications program & SCADA graphics shall meet the intent of the P&ID Contract Drawing and as listed herein.
- C. The following additional program functions shall be provided (minimum):
 - 1. Variable alarms are alarms where a variable input (i.e. level, pressure, etc.) has exceeded its predetermined high/low setpoint. Each variable alarm will have a time delay to prevent false alarms and an alarm enable/disable condition.
 - 2. Digital alarms: Receive digital inputs from field switch devices. Generate internal alarm after setpoint adjustable time delay. User shall be able to adjust time delay via the OI.
 - 3. Enable/disable and settable time delays for all analog and digital alarms settable from the OI.
 - 4. Transfer all analog and status values from all of the remote RTUs to the SCADA graphics display to match existing system.
 - 5. Calculations
 - a. Flow totalization of each flow meter signal:
 - 1) Non-resettable Totalization.
 - 2) Resettable Totalization.
 - 3) Yesterday's 24 hour flow total.

Section 16940 – Page 20
Instrumentation and Field Devices

- b. Run times & Starts for each pump:
 - 1) Non-resettable.
 - 2) Resettable.
 - 3) Yesterday's 24 hour total.
 - 4) Hourly totals
 - 5) Today's running total
- 6. All setpoints, enable/disables, time delays and registers shall be adjustable from SCADA computer.
- 7. Provide monitoring and control of existing remote SCADA system lift stations, wells and reservoirs for a complete and operable system. Provide graphics and necessary programming to match new WWTP format.
- 8. Lift Pump Control:
 - a. Pump Availability – Status determined when HOA switch is in auto and no control lockout alarms exist.
 - 1) Lead pump (A) to be taken out of sequence and control to fail over to next available pump (B) if lead pump is unavailable.
 - 2) Upon re-establishment of availability, lead pump (A) shall be placed back in pump sequence and regain lead status when available pump (B) has stopped.
 - b. Receive pumps Auto status from the motor controls. Enable pumps to start only if it shows Auto status, no Low WW Level Lockout, and no (#) Pump Fail or Lockout. Stop pumps if it is not in Auto or there is a Low WW Level Lockout, or there is a (#) Pump Fail or Lockout.
 - c. This strategy shall determine the quantity of pumps required in response to the Wetwell Level (L151). The lead pump is enabled and disabled by first stage start/stop level setpoints. The lag pump will be enabled and disabled by second stage start/stop level setpoints. Upon level transducer fail, pump shall operate based on float switches.
 - d. Pump speed to modulated based on PID control to meet adjustable speed setpoint.

- e. Pump Sequence - The following defines how the pump stage number maps to the individual pumps. A setpoint shall define the order that the pumps are called as follows:

<u>Number</u>	<u>Sequence</u>
0	Rotate all pumps first on first off.
12	Pump 1 Lead, Pump 2 Lag
21	Pump 2 Lead, Pump 1Lag

- 9. Grit Removal System Control:
 - a. Grit removal system to operate when Lift pumps are running. Provide adjustable time delays for delayed start and stop.
 - b. Provide SCADA switch to call Grit system to run on wet weather or dry weather flow.
- 10. Blower Control:
 - a. Blowers shall alternated starting to permit even runtimes for blower. Allow Operator to select fixed lead blower and alternating sequences.
 - b. All alarms, values and setpoints shall be transmitted to SCADA computer. Contractor is responsible for determining the existing RTU204 call of the blowers and transfer programming to the PLC. Monitor Aeration valve call. Blower shall also be called when Aeration valves open.
 - c. Transmit blower run status to PLC.
- 11. Aeration Valve Control: (similar for Digester except only one control variable)
 - a. Valves are called based on existing Aeration Control Panel (call to existing local valve).
 - b. When Aeration valve is called, valve shall adjust to meet adjustable DO setpoint. Control Variable shall be one of three values:
 - 1) Aeration basin East D.O.
 - 2) Aeration basin West D.O.
 - 3) (Aeration basin East D.O. + Aeration basin West D.O.) / 2
 - c. All alarms, values and setpoints shall be transmitted to SCADA computer.

Section 16940 – Page 22
Instrumentation and Field Devices

12. Scaling (minimum) to engineering values of all variables:
 - a. D.O. in 1/1000s ppm resolution
 - b. Flow in 1/100s MGD or 1s GPM resolution
 - c. Flow totalization in 1/10s Kgal resolution
 - d. Runtime in 1/10s hour resolution
13. Transducer fail alarms for all analog inputs.
14. All setpoints and registers shall be shown and adjustable from Central SCADA.

D. Operator Interface Configuration

1. The following shall be provided on the SCADA display for all ladder logic program control strategies:
 - a. Graphic screen displaying station main parameters in process flow format. Alarms shall flash amber until acknowledged and stay solid until alarm clears.
 - b. Setup control parameter screen listing all setpoint registers.
 - c. Alarm summary screens listing all alarms.
 - d. Acknowledge button to acknowledge alarms displayed on OI.
 - e. All values displayed with engineering units.
 - f. Analog values with the resolutions matching engineering scaling.
 - g. Display indicating a new alarm no matter which screen is currently displayed.
 - h. Jump button displayed on all screens to go to a menu screen listing jumps to all screens.
 - i. Jump button displayed on all screens to go to the last screen.
 - j. Text accompanying any changes in color display (i.e., green – “RUN”, red – “OFF”, etc.).

- k. Setup color convention to be used:
 - 1) Background colors:
 - a) Window – Grey.
 - b) Changeable variable points - Pale Yellow.
 - c) Non-Changeable variable points - Light Blue.
 - d) Variable points shall be displayed in a box.
 - 2) Control Switch Colors
 - a) Hand - Red.
 - b) Off - Grey.
 - c) Auto - Green.
 - 3) Pump and Equipment Colors
 - a) Run - Green.
 - b) Off - Red.
 - c) Fail - Amber.
 - d) Ready/Available - White.
 - 4) Water Valve Colors
 - a) Closed - Red
 - b) Modulating - Purple.
 - c) Fully Open - Green.
 - d) Undetermined - Grey.
 - 5) Circuit Breaker Colors
 - a) Closed - Green.
 - b) Open - Red.
 - 6) Relay Logic Colors
 - a) Closed Relay Contact - Green
 - b) Open Relay Contact - Red.
 - l. SCADA graphics representing data and alarms shown on OI screens provided by package system suppliers (i.e. RO, etc.). All alarms and data
- 2. SCADA screens shall be provided for all Contract Drawing P&IDs, including those where PLC programs are provided by others.
 - a. Contractor shall coordinate with other Suppliers to obtain PLC data to complete SCADA graphic configuration.
 - b. SCADA screens shall be provided that simulate the data displayed on Operator Interfaces provided by packaged systems. All run statuses, setpoints and alarms shall be displayed on the SCADA screens.
 - 3. Configure SCADA Graphics on new SCADA computer.
 - a. SCADA database of tagnames that are used in the Contract Documents control strategies shown on Contract Drawings and transferred between processors.

Section 16940 – Page 24
Instrumentation and Field Devices

- b. Graphic screens representing the plant process flow as shown on P&IDs. Graphic screen of the plant overview will also be updated.
 - c. Control folders listing process values and control setpoints.
 - d. Flow and runtime summary screens.
 - e. Historical Data Export of data.
 - f. Alarm annunciator screens similar to standard mechanical alarm annunciators.
 - g. PLC maintenance screens representing PLC racks and I/O input and output cards. Enable / Disable selection shall be made with two buttons. "Enable" button shall be green when enabled and grey when disabled. "Disable" button shall be red when disabled and grey when enabled.
 - h. Realtime (1, 4, 8 & 12 hour) and Historical Trends of process variables.
 - i. SCADA alarm autodialer callout on new alarms including alarms generated by PLCs provided by others under this Contract (i.e. RO PLC, etc.). A process values menu will be developed by the System Supplier with the Operators' input so they may access key values and status.
 - j. SCADA database, Graphics screens, control folders, alarm annunciator screens, PLC maintenance screens and Realtime/Historical trends shall be developed for PLCs provided by others under this Contract. System Supplier is responsible for obtaining all required information from various Contractors to develop SCADA graphics necessary for monitoring and controlling new equipment.
- E. The Contractor shall include in his bid price an additional 200 hours of PLC program and SCADA Operator Interface graphic changes to be allocation to be determined during testing and start-up by the State representative. Any hour usage shall be made after written approval by State representative. Programming changes made during factory testing shall not be deducted from these hours unless agreed upon by State's Representative. Field program changes shall be made by original programmer within five (5) working days after notification in writing by State's Representative. All programming configuration changes shall be performed by the original programmer and shall be made as directed by the State's Representative in writing. A weekly report shall be prepared by System Supplier listing extra hour utilized, dates when work was done, description of work performed, and remaining number of extra hours. None of the hours shall be used for documentation, paperwork, travel, overhead, construction management, etc. that are not related to programming

changes since this is included in the hourly rate without written approval from State's Representative. All hours not used shall be allocated for additional PLC program changes as directed by State representative during the one year warranty period.

PART 3 - EXECUTION

3.1 WORKMANSHIP

- A. All instrumentation work in this Contract shall conform to the CEC and standards.
- B. The Contractor shall employ personnel who are skilled and experienced in the installation and connection of all elements, equipment, devices, instruments, accessories, and assemblies. All installation labor shall be performed by qualified personnel who have had experience on similar projects. Provide first class workmanship for all installations.
- C. Ensure that all equipment and materials fit properly in their installations.
- D. Perform any required work to correct improper installations at no additional expense to the State.
- E. The State reserves the right to halt any work that is found to be substandard or being installed by unqualified personnel.
- F. Rejected equipment or equipment without approved Submittals shall be immediately removed from the delivery or job site by the Contractor.
- G. All Manufacturers' instructions are to be followed. One copy of O&M and installation instructions shall be made available to the State when equipment is first being installed.
- H. Before beginning SCADA software development for each process area, meet with the State for a four-hour Design Definition Meeting at the State's facility.
 - 1. Ensure that the Contractor Project Manager, System Supplier Engineer, System Supplier SCADA & PLC software programmer, Engineer & State's representative are in attendance.

Section 16940 – Page 26
Instrumentation and Field Devices

2. Discuss SCADA & PLC format, programming and setup requirements to ensure that parties involved have a clear understanding of the Contract requirements. This discussion is to cover graphic screen layout, color conventions, text display menu system, PLC ladder logic etc. System Supplier to demonstrate preliminary SCADA screen color and graphic layout by bringing a configured PC loaded with SCADA graphics to the meeting. State shall have final determination during this meeting on the color conventions, alarm handling with color and display format.
 3. System Supplier to demonstrate sample SCADA screen color and graphic layout by bringing a configured PLC and PC loaded with modified SCADA graphics to the meeting.
 4. System Supplier to provide schedule for Preliminary Design Review and Critical Design Review.
 5. Meeting shall occur 6 weeks prior to process area installation.
- I. Meet with the State for a 4-hour SCADA & PLC Preliminary Design Review meeting at the State's facility for each process area.
1. Ensure that the Contractor Project Manager, System Supplier Engineer, System Supplier SCADA & PLC software programmer, and Engineer & State's representative are in attendance.
 2. Provide SCADA & PLC software preliminary design submittals for review and discussion 10 working days prior to meeting.
 3. System Supplier to demonstrate revised SCADA screen color and graphic layout by bringing a configured PLC and PC loaded with modified SCADA graphics to the meeting.
 4. System Supplier to demonstrate complete understanding of PLC control sequence of operations and SCADA setup.
 5. System Supplier to assign action items with required completion date. Contractor to submit report of completed action items to the State on or before designated date.
 6. Meeting shall occur 4 weeks prior to process area installation.
- J. Meet with the State for a 4-hour SCADA & PLC Critical Design Review meeting at the State's facility prior to start of any factory test for each process area.
1. Ensure that the Contractor Project Manager, System Supplier Engineer, System Supplier SCADA & PLC software programmer, and Engineer and State's representative are in attendance.

2. Provide preliminary SCADA & PLC Software Operations and Maintenance Manual.
 3. System Supplier to demonstrate the complete SCADA & PLC setup. All station display and setpoint parameters will be checked for completeness by bringing PC and PLC both fully programmed & setup to the meeting.
 4. System Supplier to demonstrate all SCADA screens for review and comment.
 5. System Supplier to assign action items with required completion date. Contractor to submit report of completed action items to the State on or before designated date.
 6. Meeting shall occur two weeks prior to process area installation.
- K. All equipment installed by the Contractor shall be in accordance with the Drawings and the manufacturer's recommendations & instructions and shall operate to the State Representative's satisfaction. Follow all Manufacturers' instructions for handling, receiving, installation, and pre-check requirements prior to energization. After energization, follow manufacturer's instructions for programming, set-up and calibration of equipment. The Contractor shall be responsible for, and shall correct by repair or replacement, at his own expense, equipment which, in the opinion of the State Representative has been caused by faulty mechanical or electrical assembly by the Contractor. Necessary tests to demonstrate that the electrical and mechanical operation of the equipment is satisfactory and meets the requirements of these Specifications shall be made by the Contractor at no additional cost to the State.

3.2 INSTALLATION

- A. Install and supply all products necessary, at no additional cost to the State, to provide an operational system. This shall include the following:
1. Contract Drawings are intended to show the basic functional requirements of the instrumentation system and do not relieve the Contractor from the responsibility to provide a complete and functioning system.
 2. Provide relays, signal converters, isolators, boosters, power conditioners, circuit cards, and other miscellaneous devices as required for the proper interface.
 3. Provide analog loop isolators where required to eliminate "ground loops."
 4. All wires shall be identified with machine printed labels. Plastic wire gutters shall be used for routing of wire bundles. Wiring shall be neat and laced with plastic tie wraps.

Section 16940 – Page 28
Instrumentation and Field Devices

5. The instrumentation and accessory equipment shall be installed in accordance with the manufacturer's instructions and located as shown on the Drawings or as approved by the State Representative. When manufacturer's installation literature specifies a particular location or orientation in a process line due to measurement accuracy considerations, the installation shall be in conformance with the manufacturer's instructions.
6. Engineering scales and charts for all instruments shall be provided that match the range of instruments that monitor the process.
7. Power to instruments and instrument loops shall be from a single source if possible providing the highest integrity: e.g., from the loop primary receiving instrument/module, or from a UPS when so specified. A loop shall not be dependent on a diversity of multiple power sources, unless otherwise indicated on the Contract Drawings.

B. Instrument Installation Methods:

1. Install instruments at the location shown on the Plans or approved by the State's Representative. Instruments shall be NEMA rated for the installed location.
2. Install instruments per manufacturer's instructions at all times. Provide a copy of manufacturer's installation requirements prior to starting installation.
3. Install level and plumb.
4. All instruments shall be provided with floor stands or wall brackets as shown or required.
5. Mounting hardware, stands, channels, and spacers shall be either galvanized steel, stainless steel, or non metallic to match the NEMA rated location.
6. All screws and bolts shall be stainless steel.
7. Field instruments shall be mounted so that they can be readily approached and easily serviced, and so they do not restrict access to mechanical equipment. Field instruments not directly mounted shall be mounted on a pipe stand or local panel, unless otherwise indicated on the Drawings.
8. Field instrument enclosures shall be NEMA 4X minimum. For indoor corrosive environments, or where otherwise specified, enclosures shall be NEMA 4X.

9. Connections from rigid conduit systems to field instruments shall be made with jacketed flexible conduit with a maximum length of 3 feet.
10. Install water proof seals on all conduits to outdoor instruments. Installation shall be such that liquid shall not enter instrument or enclosure to which the conduit is connected.
11. All parameter set-up and programming shall be performed by the Contractor at no additional cost to the State.

C. Wiring and Raceway Installation Methods:

1. Instrumentation wiring shall be carried in conduits. All analog circuits shall be run as twisted pairs or triads. In no case shall a circuit be made up using conductors from different pairs or triads. Triads shall be used wherever three wire circuits are required. Triads are not to be formed by using two pairs. Terminal blocks shall be provided at all instrument cable junctions and all wires shall be identified at such junctions. Instrumentation wiring shall be run without splices between instruments, terminal boxes, or panels.
2. The number of signal wires listed on the Drawings is approximate only, and the Contractor shall determine the required number of signal pairs or triads to properly connect the system furnished, especially when substituting equipment.
3. When stipulated "manufacturer supplied cable" in the conduit schedule, it directs the Contractor to have the manufacturer supply the cable for the length of the conduit run.
4. All equipment and instrumentation located below grade shall have conduit drain boxes and plug conduit interior to form an effective barrier to keep out water traveling down conduit into equipment and instrumentation when necessary at no additional cost to the State.

D. Wiring, grounding, and shielding methods. It is important to observe good grounding and shielding practices in the generally noisy environment in this application. The following practices shall be observed unless modified by manufacturer's standards:

1. Each electronic equipment chassis shall be grounded to power ground.
2. All analog signals shall be transferred over shielded twisted pair cables.
3. All communication signals shall be transferred over shielded cables.

Section 16940 – Page 30
Instrumentation and Field Devices

4. All shields of analog inputs to the components shall be connected at the components unit only. They shall not contact ground at any other point including the transmitters.
5. All shields of analog outputs from the components shall be grounded only at the receiving device. They shall not contact ground at any other point including the components.
6. Status and alarm signals routed through noisy environment shall be transferred over shielded twisted pair cables using 24VDC control and interface relay for transition to 120VAC circuits.
7. Each shield, which is not connected to ground, shall be covered with a heat shrink insulating boot. Shields shall be connected together at each transition from one cable to another for a continuous effective shield circuit. All shields shall be connected on terminal blocks.
8. Isolating amplifiers shall be provided within the panel for field equipment creating a ground loop.

3.3 SUPPLIER SERVICES

- A. The Contractor shall be responsible for each Supplier of equipment to provide the following minimum services for each type of instrument supplied.
 1. The Supplier shall use a qualified instrumentation field technician (sales representatives are not acceptable) to perform services listed herein. Technician shall be authorized or certified by instrument manufacturer to install and start-up instrument. Provide resume of technician and related experience with related instrument prior to installation.
 2. Advise and instruct Contractor on installation requirements.
 3. Check, calibrate, and place equipment in operation.
 4. All programmable devices shall be programmed and tested prior to startup. Programming shall be adjusted or changed as directed by the State or State Representative, at no additional cost. A listing of all programming and setup parameters shall be placed in O&M manual at end of project.
 5. Coordinate with the State's Representative and setup all alarm, process, and operation setpoints.
 6. Perform the acceptance tests.
 7. Visit the job as often as required and spend as much time as necessary to ensure an operational instrumentation system.

8. Be readily available by telephone to answer all questions on supplied equipment.
9. Provide training as specified below:
 - a. General:
 - 1) Field training shall be administered on site using the delivered system in real time situations. Field training shall not start until the "field" tests on the corresponding equipment have been completed and the corresponding operating instructions have been submitted and approved.
 - 2) The "Training Plan" shall be conducted by a qualified supplier person(s), who has conducted similar training for the type of System supplied.
 - 3) Acceptable Operation and Maintenance Manuals shall be on site and available when training sessions are implemented.
 - b. Classroom Training (24 hours duration on site):
 - 1) The level of classroom training shall be sufficient to familiarize the State Representative personnel with the Plant Controls and operation.
 - 2) The level of classroom training shall be sufficient to familiarize the personnel with the operation and maintenance of the system. All essential system operating procedures shall be described as required to enable State Representative's personnel to observe the equipment operation. Preventive maintenance procedures shall be described as required to enable personnel to maintain the equipment.
 - 3) State personnel shall be trained in radio programming and control strategies prepared for this project. The level of training shall enable the State personnel to understand the program, make programming changes to the system and to debug the program.
 - 4) Utilize O&M manual and review in detail.
 - c. Field Training:
 - 1) Field training shall be held on-site after classroom training for the equipment has been completed.

- 2) Supplier shall provide field training for a minimum of eight (8) of the State's engineering, operations and maintenance personnel
 - 3) The "diagnostic and calibration" training, sixteen (16) hours minimum, shall demonstrate radio hardware diagnostic routines, test equipment, radio communication setup, and test procedures as required to enable the personnel to detect and isolate system faults to the circuit board or module level and to implement repairs by replacing failed circuit boards or modules. Demonstrate uploading and downloading software to make backups and restore programs.
 - 4) The "operator" hands-on training, twenty-four (24) hours minimum, shall be given to show to non-technical and technical State Representatives the basics in day-to-day operations and control strategies involving the electrical and control systems. Preventive maintenance procedures shall also be demonstrated for State Representative personnel during this training period.
- d. Training on each type of field device shall provide a minimum of four (4) hour of on-site field training to instruct State personnel in the use, operation, calibration, programming, and maintenance on each different type of "field" instrument. This applies all field devices.
 - e. Responsibility to provide primary elements in a timely manner, for insertion into the process line, coordinating size and material type when applicable, overseeing the actual installation, calibration, and acceptance testing.

3.4 ACCEPTANCE TESTS

A. Instrumentation tests shall be conducted per the following criteria:

1. As a minimum, all the tests indicated/specified on the test forms Instrumentation Data Sheet and Calibration Record Test Form TF-1 and Operational Device Check & Test Form TF-2 in Appendix "A" shall be performed by the Contractor as listed for the instrumentation and field devices in Appendixes "B" and "C".
2. Test equipment used for testing shall be of suitable quality so as not to mask performance deficiencies. All test equipment shall be traceable to National Bureau of Standards and have been calibrated within six months of test date.
3. Testing shall be accomplished using simulated inputs only with prior written approval of the State.

4. The overall accuracy of each instrument loop shall be checked to ensure that it is within acceptable tolerance.
 5. Calibration stickers shall be supplied for all equipment and instruments. Calibration stickers shall list the following information:
 - a. Tag number.
 - b. Calibrated by whom (name), firm, city and telephone number.
 - c. Date calibrated.
 - d. Calibration range.
 - e. Comments.
 6. The Contractor shall provide a minimum of two (2) hours of field testing for each instrument. If any instrument has not been fully tested during its allotted time, the Contractor shall provide additional hours for finishing testing of the instrument, to be paid by the Contractor.
- B. The completion of the above tests does not relieve the Contractor from warranties specified elsewhere in this division.

3.5 TRAINING

- A. Training on each type of field device shall provide a minimum of four (4) hour of field training to instruct State personnel in the use, operation, calibration, programming, and maintenance on each different type of "field" instrument. This applies all field devices.

3.6 SPARE PARTS

- A. The Contractor shall make available any replacement parts that are not manufacturer's normal stock items for immediate service and repair of all the instrumentation equipment throughout the warranty period.
- B. The following spare parts shall be provided to the State as part of this Contract:
1. Ten (10) fuses for each type of fuse.
 2. Ten (10) lamps for each type of light.
- C. Spare parts shall be packaged for safe shipping, storage, and clearly labeled with part name and number and the corresponding equipment tagname.

3.7 FINAL ACCEPTANCE

- A. Final acceptance will be given by the State after the equipment has passed the "final acceptance trial period", each deficiency has been corrected, documentation has been provided, and all the requirements of design documents have been fulfilled.
- B. At the end of the project, following the completion of the field tests, and prior to final acceptance, the Supplier shall provide the following to the State:
 - 1. Each Operation and Maintenance Manual shall be modified or supplemented by the Supplier to reflect all field changes and as-built conditions.
 - 2. A listing of all programming and setup parameters (including field instruments) for insertion into the O&M manual.

APPENDIX "A"

TEST FORMS

Index of Forms:

- TF-1 Instrumentation Data Sheet and Calibration Record Test Form
- TF-2 Operational Device Checks and Tests Form

APPENDIX "B"

16940 INSTRUMENTATION AND FIELD DEVICES INDEX