C. Painting Piping Insulation (Exposed to View):

1. Metal or PVC jacketing does not require painting.

2. If an insulated piping system is indicated to be painted:
   a. Prime coat in accordance with Section 09 90 00, Painting and Coating.
   b. Finished insulation (and not the piping) shall be painted in accordance with Section 09 90 00, Painting and Coating.

END OF SECTION

SERVICE AND INSULATION THICKNESS TABLE				
Service Type	**Thickness**	**Location**	**Insulation**	**Finish**
Potable Water 6” & Smaller	1”	Exterior Exposed	Type 1	Type F3
Alum	1”	Exterior Exposed & within Vaults	Type 1	Type F3
Sodium Hydroxide	1”	Exterior Exposed & within Vaults	Type 1	Type F3
Hydrofluorosilicic Acid	1”	Interior, Exterior Exposed, & within Vaults	Type 1	Type F3
Corrosion Inhibitor	1”	Exterior Exposed & within Vaults	Type 1	Type F3
Sodium Thiosulfate	1”	Exterior Exposed & within Vaults	Type 1	Type F3
Polymer	1”	Exterior Exposed & within Vaults	Type 1	Type F3

SECTION 40 80 01
PROCESS PIPING LEAKAGE TESTING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this Section:

1. American Water Works Association (AWWA).
   a. C600, Installation of Ductile Iron Mains and Their Appurtenances
   b. C605, Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water

1.02 APPLICABILITY AND RESPONSIBILITIES

A. The testing specified herein addresses process piping which generally includes, but is not limited to, piping carrying raw water, partially treated water, finished water, spent backwash water, sludge, filtrate, chemicals, and water samples. Also, testing of lines carrying air or hydraulic oil for valve actuation is covered under this Section along with testing of lines carrying air for filter backwashing. This Section does not address plumbing, roof drains, gas mains, or any type of fuel lines.

B. Tank and process piping vents and seal water drains do not need to be tested.

C. All testing shall be conducted by the Contractor in the presence of the Engineer. The Contractor shall furnish all equipment including plugs, caps, gauges, meters, and other equipment necessary to conduct the required tests.

1.03 SUBMITTALS

A. Testing Plan: Submit prior to testing and include at least the following information.

1. Testing dates.
2. Piping systems and sections to be tested.
3. Test type.
4. Method of isolation.
5. Calculation of maximum allowable leakage for piping sections to be tested.
6. Certifications of calibration for testing equipment.
7. Certified test report.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Notify Engineer in writing five (5) days in advance of testing. Perform testing in presence of Engineer.

B. Pressure Piping Carrying Liquids:

1. Install temporary thrust blocking or other restraint as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.
2. Wait seven (7) days minimum after concrete thrust blocking is installed to perform pressure tests. If high-early strength cement is used for thrust blocking, wait may be reduced to three (3) days.
3. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
4. New Piping Connected to Existing Piping: Isolate new piping with caps, plugs, blind flanges or as acceptable to Engineer.
5. Test Pressure: As indicated on Piping Schedule.

C. Test section may be filled with water and allowed to stand under low pressure prior to testing.

D. Gravity Drains and Filtrate Conveyance Piping:

1. When testing gravity drains or filtrate conveyance drains, perform testing after service connections, manholes, and backfilling have been completed.
2. Determine groundwater level at time of testing by exploratory holes or other method acceptable to Engineer.

3.02 HYDROSTATIC TEST FOR PRESSURE PIPING CARRYING LIQUIDS

A. In addition to pressure piping that is clearly operating under significant pressures, this testing shall be applicable low pressure piping with gravity flow, such as piping in filter and GAC contactor pipe galleries and piping between process structures.

B. Testing shall be performed in accordance with AWWA C600 and C605.

C. Fluid: Use clean water of such quality to prevent corrosion of materials in piping system.

D. Exposed Piping:

1. Perform testing on installed piping prior to application of insulation.
2. Maximum Filling Velocity: 0.25 foot per second, applied over full area of pipe.
3. Vent piping during filling.
   a. Open vents at high points.
   b. Loosen flanges if necessary.
   c. Use equipment vents if necessary
   d. Provide temporary air release points if necessary.
4. Maintain hydrostatic test pressure continuously for 60 minutes, minimum, and for such additional time as necessary to conduct examinations for leakage.
5. Examine joints and connections for leakage.
6. Correct visible leakage and retest as specified.

E. Buried Piping:

1. Test after backfilling has been completed.
2. Expel air from piping system during filling.
3. Manipulate valves to isolate test section and provide temporary plugs, caps, or blind flanges as applicable.
4. Apply and maintain specified test pressure with hydraulic force pump.
5. Maintain hydrostatic test pressure continuously for two (2) hours minimum.
6. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.
7. Maximum Allowable Leakage:

$$L = \frac{SD\sqrt{P}}{133{,}200}$$

where:

L = Allowable leakage, in gallons per hour.
S = Length of pipe tested, in feet.
D = Nominal diameter of pipe, in inches.
P = Test pressure during leakage test, in pounds per square inch.

8. Correct leakage greater than allowable, and retest as specified.

3.03 PNEUMATIC TEST FOR AIR PIPING

A. Do not perform pneumatic testing on:

1. PVC, CPVC, polyethylene or any other type of plastic pipe.

2. Buried and other non-exposed piping.

B. Pneumatic testing shall be performed on compressed air lines, air piping for filter backwashing, and lines that will carry hydraulic oil for valve actuation.

C. Fluid: Oil-free, dry air.

D. Procedure:

1. Apply preliminary pneumatic test pressure equal to 25% of the test pressure set forth in the Pipe Schedule prior to final leak testing to locate visible leaks. Apply soap bubble mixture to all joints and connections and examine for leakage.
2. Correct visible leaks and repeat preliminary test until visible leaks are corrected.
3. Gradually increase pressure in system to 50% of specified test pressure. Thereafter, increase pressure in steps of approximately 10% of the specified test pressure until required test pressure is reached.
4. Maintain pneumatic test pressure continuously for minimum of 60 minutes and for such additional time as necessary to conduct soap bubble examination for leakage.
5. Correct visible leakage and retest as specified.

E. Allowable Leakage: Piping system shall show no visual evidence of leakage.

3.04 HYDROSTATIC TEST FOR GRAVITY PIPING

A. Testing Equipment Accuracy: Plus or minus 1/2-gallon water leakage under specified conditions.

B. Maximum Allowable Leakage: 0.16 gallons per hour per inch diameter per100 feet. Include service connection footage in test section, subjected to minimum head specified.

C. Exfiltration Test:

1. Hydrostatic Head:
   a. At least 6 feet above maximum estimated groundwater level in section being tested.
   b. No less than 6 feet above top of highest section of pipe in test section, including service connections.
2. Length of Pipe Tested: Limit length such that pressure on invert of lower end of section does not exceed 30 feet of water column.

D. Infiltration Test:

1. Groundwater Level: At least 6 feet above inside top of highest section of pipe in test section, including service connections.

E. Piping with groundwater infiltration rate greater than allowable leakage rate for exfiltration will be considered defective even if the piping previously passed an exfiltration test.

F. Defective Piping Sections: Excavate and repair leaks and retest as specified. Internal repairs involving injection of sealing materials are not acceptable.

3.05 FIELD QUALITY CONTROL

A. Test Report Documentation:

1. Test date.
2. Description and identification of piping tested.
3. Test fluid.
4. Test pressure.
5. Remarks, including:
   a. Leaks (type, location).
   b. Repair/replacement performed to remedy excessive leakage.
6. Signed by Contractor and Engineer to represent that test has been satisfactorily completed.

END OF SECTION

SECTION 40 91 00
PROCESS CONTROL AND INSTRUMENTATION

PART 1 - GENERAL

1.1 REQUIREMENTS

A. The Contractor shall provide a complete and functional Process Control and Instrumentation System (PCIS), including programming of the programmable logic controllers (PLCs) and Human Machine Interfaces (HMIs).

B. The requirements of this Section apply to all components of the PCIS, unless indicated otherwise.

C. Responsibilities

1. The Contractor, through the use of an Instrumentation Supplier and qualified electrical and mechanical installers, shall be responsible for the implementation of the PCIS and the integration of the PCIS with other required instrumentation and control devices.

2. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these Specifications that the Instrumentation Supplier be responsible for the integration of the PCIS with devices provided under other Sections, with the objective of providing a completely integrated control system free of signal incompatibilities.

3. In order to provide a high degree of unity of responsibility, the Contractor shall retain an Instrumentation Supplier who shall furnish all panels, PLCs, HMIs, field instruments, signal converters, float switches, software, programming and similar components except as follows:

a. Prefabricated panels typically provided by equipment manufacturers to control their equipment shall be furnished by the respective equipment suppliers. Examples include:

- PAC feed system control panel
- Walking beam flocculator control panels
- Telescoping sludge collector control panels
- Compressed air system control panel
- Air/oil accumulator control panel
- Finished water pump check valve control and hydraulic panels

- Gravity sludge thickener control panel
- Standby generator set control panels

b. Control panels directly associated with the conventional filters and GAC contactors shall be furnished by the equipment manufacturer as stated in the respective equipment Specification Sections. Further, instruments associated with these systems such as level sensors, differential pressure transmitters, turbidimeters, and flow meters shall be provided by the filter and GAC contactor equipment manufacturers.

4. As a minimum, the Instrumentation Supplier shall perform the following duties:

a. Implementation of the PCIS

1) Prepare shop drawings in accordance with Section 01 33 00 which address compliance with the various Specifications and show the relationships with the interconnected components.

2) Prepare the testing and training plans, and the spare parts submittals.

3) Procure hardware and the necessary software for complete functioning systems.

4) Provide PLC, HMI, and other programming as specified herein and required for complete functioning systems.

5) Coordinate and cooperate with other suppliers under contract with the Owner who are providing security and fire alarm facilities.

6) Oversee and certify hardware installation.

7) Oversee, document, and certify loop testing.

8) Provide warranties and bonds in accordance with Section 01 74 00.

9) Provide operation and maintenance data in accordance with Section 01 78 23.

10) Provide record documents in accordance with Section 01 78 39.

5. Any Instrumentation Supplier responsibilities in addition to the list above are at the discretion of the Contractor and the Instrumentation Supplier. Additional requirements in this Section and throughout Division 40 which are stated to be the Contractor's responsibility may be performed by the Instrumentation Supplier if the Contractor and Instrumentation Supplier so agree.

D. Quality Assurance: The following firms are acceptable organizations that can act as the Instrumentation Supplier on the Project.

1. C2I (Control Instruments, Inc.)

2. Curry Controls Company

3. MR Systems, Inc.

4. Revere Control Systems

E. Control System Panel Designer and Fabricator

1. Control System Panel Designer and Fabricator (CSPDF): The control system panels and all other panels that have PLC hardware or communication hardware within them shall be fabricated by the CSPDF. The CSPDF may be a subcontractor to the Instrumentation Supplier or the Instrumentation Supplier itself. The CSPDF shall have the resources, space, and personnel needed to design and fabricate the panels. The CSPDF shall meet the following minimum qualifications:

a. The CSPDF shall have been in the business of building panels and bonding the construction of these panels for at least five (5) years. The bonding shall be under the name and ownership of the company fabricating the panels for this project.

b. The CSPDF shall build the panels to UL Standard 508A, shall be certified to build panels to UL standard 508A, and shall attach a UL label on all new panels, or the panel builder shall build to an equal standard, shall be certified to an equal standard, and shall attach a label to all new panels with a label that is acceptable to the Engineer.

1.2 SUBMITTALS

A. Shop Drawings shall be submitted in accordance with Section 01 33 00. Additional specifics are outlined below.

1. Symbology and Nomenclature: In the Contract Drawings all systems, all meters, all instruments, and all other elements are represented schematically, and are designated by symbology as derived from Instrument Society of America Standard ANSI/ISA S5.1 – Instrumentation Symbols and Identification. The nomenclature and numbers designated herein and on the Drawings shall be employed exclusively throughout Shop Drawings, and similar materials. No other symbols, designations, or nomenclature unique to the manufacturer's standard methods shall replace those prescribed above, used herein, or on the Drawings.

2. Analog Hardware Submittal: The Contractor shall submit an analog hardware submittal as a complete bound package at one (1) time within 90 calendar days after the Notice to Proceed. This submittal shall include:

   a. A complete index which lists each device by tag number, type, and manufacturer. A separate technical brochure or bulletin shall be included with each instrument data sheet (original documents only – photocopies are not acceptable and will be rejected). The data sheets shall be indexed in the submittal by systems or loops, as a separate group for each system or loop. If, within a single system or loop, a single instrument is employed more than once, one data sheet with one brochure or bulletin may cover all identical uses of that instrument in that system. Each brochure or bulletin shall include a list of tag numbers for which it applies. System groups shall be separated by labeled tags.

   b. Fully executed data sheets according to ISA-TR20 for each component, together with a technical product brochure or bulletin. The technical product brochures shall be complete enough to verify conformance to all Contract Document requirements. The data sheets, as a minimum, shall show:

      1) Component functional description used in the Contract Documents.

      2) Manufacturer's model number or other product designation.

      3) Project tag number.

      4) Project system or loop of which the component is a part.

      5) Project location or assembly at which the component is to be installed.

6) Input and output characteristics.

7) Scale, range, units, and multiplier (if any).

8) Requirements for power supply (if any).

9) Requirements for air supply (if any).

10) Materials of component parts to be in contact with or otherwise exposed to process media and corrosive ambient air.

11) Special requirements or features.

c. Priced list of all spare parts for all devices.

d. Instrument installation, mounting, and anchoring details shall be submitted. Each instrument shall have a dedicated 8-1/2- inch by 11-inch detail which only pertains to the specific instrument by tag number. Each detail shall be certified by the instrument manufacturer that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable. As a minimum, each detail shall have the following contents:

1) Show all necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.

2) Process line pipe or tank size, service and material.

3) Process tap elevation and location.

4) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.

5) Routing of tubing and identification of supports.

6) Mounting brackets, stands, and anchoring devices.

7) Conduit entry size, number, location, and delineation between power and signal.

8) NEMA ratings of enclosures and all components.

9) Clearances required for instrument servicing.

10) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

3. Test Procedure Submittals

a. Submit the proposed procedures to be followed during tests of the PCIS and its components.

b. Submit outlines of the specific proposed tests and examples of proposed forms and checklists.

PART 2 - PRODUCTS

2.1 GENERAL CONTROLS REQUIREMENTS

A. Code and Regulatory Compliance: PCIS work shall conform to or exceed the applicable requirements of the National Electrical Code and local building codes.

B. Current Technology: Meters, instruments, and other components shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the Shop Drawings, unless otherwise required to match existing equipment.

C. Hardware Commonality: Instruments which utilize a common measurement principle shall be furnished by a single manufacturer. The Instrumentation Supplier shall coordinate with the manufacturer of the filter and GAC contactor equipment to ensure uniformity in flow metering equipment, level sensors, and turbidimeters. Panel-mounted instruments shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer.

D. Loop Accuracy: The accuracy of each instrumentation system or loop shall be determined as a probable maximum error; this shall be the square-root of the sum of the squares of certified "accuracies" of the designated components in each system, expressed as a percentage of the actual span or value of the measured variable. Each individual instrument shall have an accuracy of plus and minus 2 percent of full scale or better and a repeatability of plus and minus 1 percent of full scale or better when installed in the field, unless otherwise indicated. Instruments that do not conform to or improve upon these criteria are not acceptable.

E. Instrument and Loop Power: Power requirements and input/output connections for all components shall be verified. Power for transmitted signals shall, in general, originate in and be supplied by the control panel devices. The use of "2-wire" transmitters is preferred, and use of "4-wire" transmitters shall be minimized. Individual loop or redundant power supplies shall be provided as required by the manufacturer's instrument load characteristics to ensure sufficient power to each loop component. Power supplies shall be mounted within control panels or in the field at the point of application.

F. Loop Isolators and Converters: Signal isolators shall be provided as required to ensure adjacent component impedance match where feedback paths may be generated, or to maintain loop integrity during the removal of a loop component. Dropping precision wire wound resistors shall be installed at all field side terminations in the control panels to ensure loop integrity. Signal conditioners and converters shall be provided where required to resolve any signal level incompatibilities or provide required functions.

G. Environmental Suitability: Indoor and outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents. Heating, cooling, and dehumidifying devices shall be provided in order to maintain all instrumentation devices within the minimums and maximums of their rated environmental operating ranges. The Contractor shall provide power wiring for these devices. Enclosures suitable for the environment shall be furnished. All instrumentation in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

H. Signal Levels: Analog measurements and control signals shall be as indicated herein, and unless otherwise indicated, shall vary in direct linear proportion to the measured variable. Electrical signals outside control panels shall be 4 to 20 mA DC, except as indicated. Signals within enclosures may be 1-5 VDC. Electric signals shall be electrically or optically isolated from other signals. Pneumatic signals shall be 3 to 15 psig, with 3 psig equal to 0 percent, and 15 psig equal to 100 percent.

I. Alternative Equipment and Methods: Equipment or methods requiring redesign of any project details are not acceptable without prior written approval of the Engineer through the "or equal" process. Any proposal for approval of alternative equipment or methods shall include evidence of improved performance, operational advantage and maintenance enhancement over the equipment or method indicated, or shall include evidence that an indicated component is not available. To match existing equipment and future equipment being installed under other contracts, equipment substitutions for equipment specified as no equal will not be accepted.

J. Instrument Brackets and Mounting Hardware: All instrument brackets and mounting hardware shall be provided and shall be of Type 316 stainless steel.

2.2 OPERATING CONDITIONS

A. The PCIS shall be designed and constructed for satisfactory operation and long, low maintenance service under the following conditions:

1. Environment - water treatment/supply facility.

2. Indoor Temperature Range - 32 through 110 degrees F.

3. Relative Humidity - 20 through 90 percent, non-condensing.

4. Seismic Zone – 4.

5. Outdoor temperature Range - -40°F to 120°F.

2.3 SPARE PARTS AND SPECIAL TOOLS

A. The Contractor shall provide spare parts as listed in Section 40 95 14.

B. The Instrumentation Supplier shall furnish a priced list of all special tools required to calibrate and maintain the instrumentation provided under the Contract Documents. After approval, the Instrumentation Supplier shall furnish tools on that list.

C. Special tools and spare parts shall be submitted before startup commences, suitably wrapped and identified.

PART 3 - EXECUTION

3.1 PRODUCT HANDLING

A. Shipping Precautions: After completion of shop assembly, factory test, and approval, equipment, cabinets, panels, and consoles shall be packed in protective crates and enclosed in heavy-duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the Site.

B. Special Instructions: Special instructions for proper field handling, storage, and installation required by the manufacturer shall be securely attached to each piece of equipment prior to packaging and shipment.

C. Tagging: Each component shall be tagged to identify its location, instrument tag number, and function in the system. A permanent stainless steel tag attached and stamped with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment in the PCIS. Identification shall be prominently displayed on the outside of the package.

D. Storage: Equipment shall not be stored outdoors. Equipment shall be stored in dry, permanent shelters, including in-line equipment, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the Contractor. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through tests as directed by the Engineer. If such tests reveal defects, the equipment shall be replaced.

3.2 INSTALLATION

A. General:

1. Instrumentation, including instrumentation furnished under other Divisions, shall be installed in accordance with the manufacturer's recommendations.

2. Equipment Locations: The configurations shown on the Drawings are diagrammatic. The locations of equipment are approximate. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. Equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Where job conditions require reasonable changes in approximated locations and arrangements, or when the Owner exercises the right to require changes in location of equipment which do not impact material quantities or cause material rework, the Contractor shall make such changes without additional cost to the Owner.

B. Conduit, Cables, and Field Wiring

1. Conduit shall be provided under Division 26.

2. Process equipment control wiring, 4-20 mA signal circuits, signal wiring to field instruments, PLC input and output wiring and other field wiring and cables shall be provided under Division 26.

3. Terminations and wire identification at PCIS equipment furnished under this or any other Division shall be provided under Division 40.

C. Instrumentation Tie-Downs: Instruments, control panels, and equipment shall be anchored by methods that comply with seismic requirements applicable to the Site.

D. Ancillary Devices: The Drawings show general intent for all necessary conduit and instruments required to make a complete instrumentation system. The Contractor shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements. Such additions and such changes, including the proposed method of installation, shall be submitted to the Engineer for approval prior to commencing the work. Such changes shall not be a basis of claims for extra work or delay.

E. Installation Criteria and Validation: Field-mounted components and assemblies shall be installed and connected according to the requirements below:

1. Installation personnel shall be instructed on installation requirements of the Contract Documents, local codes, and manufacturer's recommendations.

2. Technical assistance must be available to installation personnel at least by telephone.

3. Installation personnel have at least one (1) copy of the approved Shop Drawings and data.

4. Flexible cables and capillary tubing shall be installed in flexible conduits. The lengths shall be sufficient to withdraw the element for periodic maintenance.

5. Power and signal wires shall be terminated with crimped type lugs (Ring, Fork, or Pin style).

6. Connectors shall be, as a minimum, watertight.

7. Wires shall be mounted clearly with an identification tag that is of a permanent and reusable nature.

8. Wire and cable shall be arranged in a neat manner and securely supported in cable groups and connected from terminal to terminal without splices, unless specifically approved by the Engineer. Wiring shall be protected from sharp edges and corners.

9. Mounting stands and bracket materials and workmanship shall comply with requirements of the Contract Documents.

10. Verify the correctness of each installation, including polarity of electric power and signal connections, and make sure process connections are free of leaks. The Contractor shall certify in writing that discrepancies have been corrected for each loop or system checked out.

3.3 CALIBRATION

A. General: Devices provided under Division 40 shall be calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.

B. Calibration Points: Each instrument shall be calibrated at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Testing Standards.

C. Bench Calibration: Instruments that have been bench-calibrated shall be examined in the field to determine whether any of the calibrations are in need of adjustment. At a minimum, 20% of bench calibrated devices shall be recalibrated in the field. Such adjustments shall be made only after consultation with the Engineer.

D. Field Calibration: Instruments that were not bench-calibrated shall be calibrated in the field to insure proper operation in accordance with the instrument loop diagrams or specification data sheets.

E. Analyzer Calibration: Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. Samples and sample gases shall be furnished by the manufacturers.

F. Calibration Sheets: Each instrument calibration sheet shall provide the following information and a space for sign-off on individual items and on the completed unit:

1. Project name.

2. Loop number.

3. Tag number.

4. Manufacturer.

5. Model number.

6. Serial number.

7. Calibration range.

8. Calibration data: Input, output, and error at 20 percent, 60 percent and 100 percent of span.

9. Switch setting, contact action, and deadband for discrete elements.

10. Space for comments.

11. Space for sign-off by Instrumentation Supplier and date.

12. Test equipment used and associated serial numbers.

G. Calibration Tags: A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the Engineer. The Contractor shall have the Instrumentation Supplier sign the tag when calibration is complete. The Engineer will sign the tag when the calibration and testing has been accepted.

3.4 LOOP TESTING

A. General: Individual instrument loop diagrams per ISA Standard S5.4 - Instrument Loop Diagrams, expanded format, shall be submitted to the Engineer for review prior to the loop tests. The Contractor shall notify the Engineer of scheduled tests a minimum of 30 days prior to the estimated completion date of installation and wiring of the PCIS. After the Engineer's review of the submitted loop diagrams for correctness and compliance with the Specifications, loop testing shall proceed. The loop check shall be witnessed by the Engineer.

B. Control Valve Tests: Control valves, cylinders, drives and connecting linkages shall be stroked from the operator interface units as well as local control devices and adjusted to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position. Control valve actions and positioner settings shall be checked with the valves in place to insure that no changes have occurred since the bench calibration.

C. Instrument and Instrument Component Validation: Each instrument shall be field-tested, inspected, and adjusted to its indicated performance requirement in accordance with manufacturer's specifications and instructions. Any instrument which fails to meet any Contract requirement, or, in the absence of a Contract requirement, any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced at the Contractor's expense.

D. Loop Validation: Controllers and electronic function modules shall be field-tested and exercised to demonstrate correct operation of the hardware and wiring. Control loops shall be checked under simulated operating conditions by impressing input signals at the primary control elements and observing appropriate responses at registers in the PLC processors. Actual signals shall be used wherever available. Following any necessary corrections, the loops shall be retested.

E. Loop Validation Sheets: The Instrumentation Supplier shall prepare loop confirmation sheets for each loop covering each active instrumentation and control device including simple hand switches and lights. Loop confirmation sheets shall form the basis for operational tests and documentation. Each loop confirmation sheet shall cite the following information and shall provide spaces for sign-off on individual items and on the complete loop by the Instrumentation Supplier:

1. Project name.

2. Loop number.

3. Tag number, description, manufacturer and model number for each element.

4. Installation bulletin number.

5. Specification sheet number.

6. Adjustment check.

7. Space for comments.

8. Space for loop sign-off by Instrumentation Supplier and date.

9. Space for Engineer witness signature and date

F. Loop Certifications: When installation tests have been successfully completed for all individual instruments and all separate analog control networks, a certified copy of each test form signed by the Engineer as a witness, with test data entered, shall be submitted to the Engineer together with a clear and unequivocal statement that the instrumentation has been successfully calibrated, inspected, and tested.

3.5 FIELD QUALITY CONTROL

A. Refer to Section 40 96 35 for detailed requirements for field testing.

END OF SECTION

SECTION 40 91 19.26
PRESSURE MEASUREMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes the following:
   1. Pressure switches.
   2. Pressure transmitters.

1.02 SUBMITTALS

A. Shop Drawings: Submit in accordance with Sections 01 33 00 and 40 91 00 covering the items included under this Section.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with specified requirements, manufacturers offering products which may be incorporated in Work include:
   1. Pressure Switches:
      a. Ashcroft
      b. Allen-Bradley
      c. Mercoid Corp.
      d. Square D.
      e. United Electric Controls

   2. Pressure Transmitters:
      a. ABB Kent-Taylor.
      b. Foxboro.
      c. Rosemount.

2.02 PRESSURE SWITCHES

A. Pressure switches shall be rated 3 amps at 120 volt AC with SPDT or DPDT contacts as shown on Drawings.

B. Pressure switches shall have an adjustable differential.

C. Proper ranges and NEMA 12, 4, 4X or 7 housing requirements shall be as shown on Drawings. Contractor shall obtain the proper device for each application.

D. If there is insufficient data on Drawings to determine range, overpressure, differential, and number of poles on switch, Contractor shall obtain information from ENGINEER.

E. Shop Drawings shall show switch model number, range, differential, overpressure, and contact data.

F. Single-pole switches and a relay will not be accepted as a substitute for 2-pole switches. Two single-pole switches individually set will not be accepted as a substitute for 2-pole switches.

G. Pressure switch parameters vary greatly with manufacturers. If, in the judgment of Engineer, pressure switch submitted is operating at limits of range, overpressure, or differential, it will not be accepted if another manufacturer has a more appropriate device for application.

H. Pressure switches are necessary at various locations within the Project and shall be supplied with the equipment they are associated with. Pressure switches do not need to be provided by the Instrumentation Supplier.

2.03 PRESSURE TRANSMITTERS

A. Pressure to current signal converter shall be 2-wire, solid-state electronic, temperature-compensated, strain gauge or capacitive type. Process pressure shall be applied to sealing diaphragm in measuring section. This pressure shall be transmitted to a measuring element connected to the electronics of the transmitter. Converter shall include a repairable circuit board mounted in a cast aluminum explosion-proof housing. Transmitter shall output an isolated 4-20 mA signal proportional to pressure measurement. Adjustable electronic damping shall be provided from 0 to 16 seconds in electronically adjustable increments of 0.1 second.

B. Positive overage protection shall be provided to 2,000 psig. Diaphragms and wetted parts shall be Type 316 stainless steel, except where other special alloys are required to prevent corrosion.

C. Accuracy shall be within plus or minus 0.1 percent of calibrated span for spans from 1:1 to 15:1 of URL. Stability shall be plus or minus 0.1 percent of URL for 6 months. Zero suppression and elevation shall be at least 500 percent of range.

D. Snubbers shall be provided in pressure tap line with an electronic signal time constant which will reduce pressure transients to plus or minus 1 percent of calibrated span. Time constant is to be achieved by placing it in panel providing power to pressure transmitter.

E. Units shall be supplied with an integral digital indicator calibrated 0 to 100 percent. Provide hand-held configurator if unit can not be set up locally.

F. Pessure Transmitter Schedule:

Description/Location	Supplier	Service/Rating Requirements
Raw Water Pump Station Pressure Transmitter/East Side of Raw Water Pump Manifold	Instrumentation Supplier	100 Degree F 100 psi Water Service Rating Required
Raw Water Pump Station Pressure Transmitter/West Side of Raw Water Pump Manifold	Instrumentation Supplier	100 Degree F 100 psi Water Service Rating Required
Backwash Blower Discharge Pressure Transmitter/Blower Discharge Manifold	Instrumentation Supplier	200 Degree F 10 psi Air Service Rating Required
Compressed Air System Pressure Transmitter/Compressed Air System Piping	Instrumentation Supplier	200 Degree F 200 psi Air Service Rating Required
Finished Water Pump Station Pressure Transmitter/Finished Pump Manifold	Instrumentation Supplier	100 Degree F 200 psi Water Service Rating Required
Backwash Pump Pressure Transmitter/Backwash Pump Discharge Piping	Instrumentation Supplier	100 Degree F 50 psi Water Service Rating Required
Elevated Backwash Water Storage Tank Pressure (Level) Transmitter/ Elevated Storage Tank Riser	Instrumentation Supplier	100 Degree F 50 psi Water Service Rating Required

PART 3 - EXECUTION

3.01 GENERAL

A. Install equipment in accordance with the manufacturer's recommendations..

END OF SECTION

SECTION 40 91 19.36
TEMPERATURE MEASUREMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes the following:

1. RTD temperature sensors.

2. Thermocouples.

3. Temperature switches.

B. Devices furnished under this Section shall be provided by the various equipment manufacturers and do not need to be part of the Instrumentation Suppliers scope of supply as described in Section 40 91 00.

1.02 SUBMITTALS

A. Shop Drawings: Submit in accordance with Section 01 33 00and Section 40 91 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with specified requirements, manufacturers offering products which may be incorporated in Work include:

1. RTD Temperature Sensors:
   a. ABB.
   b. Rosemount.

2. Thermocouples:
   a. Foxboro.
   b. Honeywell.
   c. Moore Industries.
   d. Riley.

3. Temperature Switches:
   a. Ashcroft.
   b. Honeywell.
   c. Mercoid.

d. United Electric Controls.

2.02 RTD TEMPERATURE SENSOR

A. Microprocessor-based temperature transmitter shall convert an RTD temperature input to a proportional 4-20 mA current output signal. Transmitter shall be a true 2-wire, 4 to 20 mA DC transmitter. Transmitter shall be field programmable from face of unit (without a hand-held programmer or programming software) and shall be configured for ranges shown on Drawings.

1. Power: Requirements: 12 to 42 volt DC.

2. Housing: NEMA 7 unless otherwise noted.

3. Output:
   a. Two-wire.
   b. Isolated 4-20 mA.

4. Range Adjustments:
   a. Zero: 0 to 100 percent non-interacting.
   b. Span: 0 to 100 percent non-interacting.

5. Accuracy: Plus or minus 0.25 degree F

6. Display:
   a. Local 4-digit digital display 2/units.
   b. Local 0 to 100 percent bar graph.
   c. 7-character alphanumeric display for local programming.

7. Operator Interface: Local keyboard.

8. Environmental: -40 to 167 degrees F.

B. Transmitter shall have automatic self-diagnostics, be automatic self-calibrating, and shall be digitally ambient temperature compensated.

C. RTD sensor shall be an enclosed connection head type unit pre-wired at factory with three (3) No. 22 silver-plated, standard copper, Teflon-insulated wires. RTD element shall be platinum with a resistance of 100 ohms at 0 degrees C, shall be of 0.10 percent precision, and shall conform to IEC 751:1983 Standards.

1. Thermowell Type:
   a. 3/4-inch NPT threaded well, tapered shank.
   b. Type 316 stainless steel.

c. Explosion-proof epoxy-coated housing with cap and chain as required per the National Electric Code.
d. Sealed, moisture-proof, 4-wire element.

2. Probe:
   a. Corrosion-resistant, 1.4-inch Type 316 stainless steel sheath.
   b. Spring-loaded fitting.
   c. Type 316 stainless steel union coupling and nipples.
   d. -325 to 900 degree F.
3. Wiring: By manufacturer

D. Sensor length shall be determined by Contractor to make good thermal contact with a representative portion of process material to ensure accuracy. Refer to installation details for further information on mounting hardware required.

2.03 THERMOCOUPLES

A. Thermocouples, wire, and extension wire shall conform to ANSI Specification C96.1 - 1964 for thermocouple systems employing Type J or K elements. Temperature range for Type K shall be 32 to 2,300 degrees F with a chromel-alumel junction. For Type J, temperature range shall be 300 to 1,400 degrees F with an iron-constantan junction. Units shall be of button type or shall employ a straight sensing assembly with a metal full-length protecting tube. Furnish sufficient extension wire to reach receiving instrument without splicing. Wire color coding shall conform to ANSI Standards. Wire insulation shall be PVC except in installations where wire temperature may exceed 200 degrees F, in which case a higher temperature insulation shall be supplied.

B. Thermocouple transmitters shall convert non-linear temperature signal and convert it to a linear 4-20 mA DC signal with an accuracy of 1.0 percent of span. Converter shall be matched to associated thermocouple materials and temperature range. Unit shall be provided with an integral or conduit mounted indicator. The temperature indicator shall be plus or minus 1 percent accurate and marked in degrees with a range as shown.

2.04 TEMPERATURE SWITCHES

A. Temperature switches shall be of remote bulb type with capillary tube. Bulbs shall be stainless steel with 0.75-inch NPT mounting for insertion directly into process pipelines. Bulb support and 0.75-inch NPT stainless steel well shall be provided. Capillary tubing of stainless steel shall be supplied with switch assembly and be of 12-foot minimum length.

B. Deadband (differential) shall be adjustable. Contacts shall be SPDT or DPDT as shown on Drawings and be rated for at least 3 amps continuous at 120 volt AC. Enclosures shall be suitable for wall mounting and be of NEMA type 4 construction.

PART 3 - EXECUTION

3.01 GENERAL

A. Install and test devices provided under this Section in accordance with the manufacturer's recommendations and Section 40 91 00.

END OF SECTION

SECTION 40 91 23.33
FLOW PROCESS MEASUREMENT DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Magnetic flow meters.

2. Ultrasonic level sensors/flow meters.

B. Refer to Section 40 91 23.36 for specific requirements associated with ultrasonic level sensors/flow meters.

1.02 SUBMITTALS

A. Submit Shop Drawings in accordance with Section 01 33 00 and Section 40 91 00. Include the following:

1. Data sheets and catalog literature for the magnetic flow meter and the microprocessor based converter/transmitter.

2. Connection diagrams for equipment wiring.

3. List of spare parts and optional equipment.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with specified requirements, manufacturers offering products which may be incorporated in Work include:

1. Magnetic Flow Meters:
   a. ABB.
   b. Endress+Hauser.
   c. Krohne.
   d. Rosemount.

2. Ultrasonic Level Sensors/ Flow Meters: Refer to Section 40 91 23.36 for specific requirements associated with ultrasonic level sensors/flow meters.

2.02 MAGNETIC FLOW METERS

A. Magnetic flow meters shall be flanged.

B. Meter body shall be Schedule 10, Type 304 stainless steel or Schedule 40 steel. Process connections shall be as specified on Drawings and Schedule, or as required to meet the requirements of the application.

C. Liner material shall be hard rubber that is in compliance with NSF Standard 61.

D. Electrodes shall be suitable for the process flow indicated on the Drawings and Schedule and shall be bullet nosed style.

E. Start-up and acceptance check for flow meters shall be performed by a qualified employee of flow meter manufacturer. Service personnel of sales representative or of equipment supplier of this Section will not be accepted.

F. Meter below grade in vaults shall be capable of withstanding continuous submergence in up to 30 feet of water without damage. The sensing element shall be constructed of suitable materials to withstand submergence to 30 feet to IP 68 rating indefinitely. Field coil design shall be such that they shall not overheat or otherwise be damaged if flow tube is not totally filled with fluid. Magnetic flow meters shall be provided with 2 grounding rings.

G. Magnetic flow meter signal converter shall consist of solid-state, feedback-type microprocessor circuitry. Operational parameters shall be user configurable locally via an integral push-button arrangement or via a remote intelligent terminal. Appurtenances, including hand-held programmer and/or programming software, shall be provided for local configuration of operational parameters. Converter shall change a low-level flow signal from sensor electrodes into a proportional isolated 4-20 mA DC signal. The converter shall have an extremely high input impedance and not be affected by quadrature noise. The unit shall be capable of accommodating uni-directional or bi-directional flow. Sensing of meter failure shall activate a user-configurable zero or 130 percent output signal.

I. Where indicated on Drawings, a high-frequency digital proportional output shall be provided for use with high-accuracy totalizers. To eliminate errors, the converter shall incorporate an integral zero return circuit to provide a constant zero output signal. An automatic empty pipe detector and low-flow cutoff shall be provided as standard.

J. Magnetic flow meters shall be electronically isolated for grounding. Where insulated or nonconductive pipe is used, only orifice plate-type grounding rings will be acceptable. Grounding electrodes which penetrate the liner will not be acceptable.

K. Units shall be supplied with an integral or local conduit-mounted flow indicator calibrated in engineering units. Indicator shall be tagged showing design range in units being measured and shall be capable of simultaneously displaying flow rate and totalization with an alphanumeric display.

L. Zero stability shall be achieved by pulsing the sensing head magnetic field coils with a regulated direct current, first in one direction and then in opposite direction.

M. Continuous zero stability shall be obtained by signal sampling during the quiescent coil states. There shall be no zero offset or zero adjustments required. The converter shall not require calibration over its expected life under normal use.

N. Flow meter shall operate within Specifications on 120 volt AC plus 10 percent and 60 Hertz plus 5 percent. Power consumption shall not exceed 25 VA for meters 24 inches and smaller, and 50 VA for meters 30 inches or greater.

O. Input span shall be adjustable between 0-1 and 0-30 feet per second and range adjustment shall be digital. Converter shall include adjustable damping circuitry. Unit shall not be affected by power line aberrations such as those produced by SCR-type motor controllers or other voltage transients.

P. System accuracy, including primary magnetic flow meter, shall be plus 0.5 percent of rate (reading) for maximum flow velocities from 1.33 to 33.33 feet per second, and plus 1 percent of rate for maximum flow velocities from 0.33 to 1.32 feet per second. Repeatability shall be plus 0.1 percent of span. Rangeability shall meet or exceed 30:1 turndown.

Q. The signal converter portion of the magnetic flow meter shall include both a magnetic driver to power the magnetic coils and the signal converter electronics. The converter shall have the ability to be either integrally or remotely mounted as specified or shown on the Drawings. If not specified or shown on the Drawings, converter shall be remotely mounted. The converter shall be housed in a NEMA 4X case. When remotely mounted, the signal cable shall be provided with the proper length.

R. Magmeter manufacturer shall comply with ISO 9000 Standards and the meter. Signal converters shall be interchangeable without effect of meter accuracy or the need for recalibration for all meter sizes.

2.03 FLOW METER SCHEDULE

A. A flow meter schedule is provided at the end of this Section.

PART 3 EXECUTION

3.01 MAGNETIC FLOW METER CALIBRATION AND TESTING

A. Each flow meter shall be tested and flow calibrated on certified testing apparatus at the manufacturer's works or other approved flow calibration facility with calibrated test equipment traceable to American or international standards. The following tests shall be conducted:

1. Pressure test to 150% of the required working pressure for 30 minutes.

2. Three-point wet flow calibration for the complete flow detector head and flow converter to verify the accuracy over the full flow range (in accordance with BS EN ISO 6817; for bi-directional flowmeters, separate tests shall be carried out with water flow in normal and reverse directions.

3. Degree of protection of the flow detector head to BS EN 60529 IP 68. Type test reports/certificates will be accepted as an alternative.

B. Details of the flow calibration test including the flow meter test rig arrangement and calibration methods shall be submitted in the tender for assessment. All test results/certificates for the flow meter shall be submitted to the Engineer prior to delivery of the equipment.

3.02 GENERAL

A. Examination, Installation, Field Quality Control, Demonstration: In accordance with Section 40 91 00.

3.03 FIELD QUALITY CONTROL

A. Installation Check: The manufacturer shall provide the services of a factory-trained representative to check the installation of all equipment installed in this Section.

1. Satisfactorily calibrate each instrument and instruct the plant personnel in the operation and maintenance of each component.

B. Manufacturer's representative shall include a half-day of start-up service by a factory-trained technician.

1. Contractor will schedule a date and time for start-up.

2. Contractor shall schedule the following people to be present during the start-up procedure.

a. Contractor
b. Company factory trained representative
c. Owner's personnel

FLOW METER SCHEDULE				
Flow Meter Description/Location	**Type**	**Size**	**Supplier**	**Remarks**
Raw Water Flow Meter/Adjacent to Flocculation Basins	Magnetic	30"	Instrumentation Supplier	Above-grade Installation
Filter No. 1 Effluent Flow Meter/Filter Pipe Gallery	Magnetic	16"	Filter Equipment Supplier	Above-grade Installation
Filter No. 2 Effluent Flow Meter/Filter Pipe Gallery	Magnetic	16"	Filter Equipment Supplier	Above-grade Installation
Filter No. 3 Effluent Flow Meter/Filter Pipe Gallery	Magnetic	16"	Filter Equipment Supplier	Above-grade Installation
Filter No. 4 Effluent Flow Meter/Filter Pipe Gallery	Magnetic	16"	Filter Equipment Supplier	Above-grade Installation
GAC Contactor No. 1 Effluent Flow Meter/GAC Contactor Pipe Gallery	Magnetic	16"	GAC Contactor Equipment Supplier	Above-grade Installation
GAC Contactor No. 2 Effluent Flow Meter	Magnetic	16"	GAC Contactor Equipment Supplier	Above-grade Installation
GAC Contactor No. 3 Effluent Flow Meter	Magnetic	16"	GAC Contactor Equipment Supplier	Above-grade Installation
GAC Contactor No. 4 Effluent Flow Meter	Magnetic	16"	GAC Contactor Equipment Supplier	Above-grade Installation
Backwash Water Flow Meter	Magnetic	24"	Instrumentation Supplier	Below-grade vault installation
Finished Water Flow Meter	Magnetic	36"	Instrumentation Supplier	Below-grade vault installation

FLOW METER SCHEDULE				
Flow Meter Description/Location	**Type**	**Size**	**Supplier**	**Remarks**
GAC Contactor Bypass Flow Meter/GAC Contactor Influent Channel	Ultrasonic Level/Flow	N/A	GAC Contactor Equipment Supplier	Refer to Section 40 91 23.26
Backwash Water Outfall Flow Meter/Outfall Flow Measurement Box	Ultrasonic Level/Flow	N/A	Instrumentation Supplier	Refer to Section 40 91 23.26
Note: When a particular type of instrument is furnished by separate suppliers the instruments shall be products of the same manufacturer to provide standardization.				

END OF SECTION

SECTION 40 91 23.36
LEVEL MEASUREMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes the following:

1. Cord type float switches.

2. Bubblers.

3. Sonic level transmitters.

1.02 SUBMITTALS

A. Shop Drawings: Submit in accordance with Section 01 33 00 and Section 40 90 00, Shop Drawings covering the items included under this Section.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with specified requirements, manufacturers offering products which may be incorporated in Work include:

1. Cord Type Float Switches:
   a. Custom Switches.
   b. Anchor Scientific.

2. Bubblers:
   a. Brooks.
   b. Honeywell.
   c. Krohne.
   d. Lesman.
   e. Uehling.

3. Sonic Level Transmitters:
   a. ABB.
   b. Endress & Hauser.

c. Rosemount.
d. Siemens.

2.02 FLOAT SWITCH (CORD TYPE)

A. Direct acting float switch shall be furnished to automatically detect liquid level change. Liquid rise of 1 inch from rest position shall operate float switch and reset will occur when liquid level drops 1 inch. Mounting shall be to a 1-inch vertical pipe for multiple float applications or to a flange for a single float application as shown. Free cable hanging floats with weights shall not be acceptable unless shown otherwise.

B. Float switch shall consist of Type 316 type stainless steel housing, mounting clamp for 1-inch-diameter pipe, flexible 3-conductor cable with a synthetic rubber jacket, and mercury-free switch. Inside float housing will be a (normally open/closed) mercury-free switch potted in epoxy. Electrical load for switch contacts shall be rated 115 volts AC at 0.5 horsepower inductive load.

C. Three-conductor cable shall be 14 AWG with 105 strands per conductor made for heavy flexing service and underwater use. A green grounding wire shall connect internally to float housing.

D. Where mercury-free float switches are required, provide float with molded ABS housing and Form C contact switch. Contractor shall ensure ampere rating is suitable for load shown on Drawings.

2.03 BUBBLER

A. Bubbler assembly shall consist of an air set, 3-position duplex selector valve, air purge regulator with rotameter, water purge rotameter, and water bypass valve. All bubblers are to be factory assembled and pre-piped in a 10-gauge steel subplate with turned edges. Bulkhead fittings shall be used for all supply and outlet connections to subplate bubbler assembly as shown on the Drawings.

B. Air set assembly shall include a pressure regulating valve with indicating gauge, filter assembly, and a ball valve.

C. Pressure regulating valve shall have 0.375-inch ports, self-venting mechanism, and a screw handle for adjusting output range from 0-30 psi.

D. Indicating gauge shall be a 2- or 2.5-inch dial with a 0-30 psi range and 1 psi graduations. Accuracy shall be 2 percent at mid-scale.

E. Filter assembly shall be a self-drain type with 0.375-inch ports, cast aluminum bowl and a 40 micron filter type element.

F. A 2-way ball valve shall be provided on outlet side of pressure regulating air set.

G. Duplex valve shall be a Conant 2-stack, 5-way, 3-position, 180-degree unit with mechanical stops and mid-position detents. Alternatively, a duplex valve can be provided which shall be a Versa Products VHA-8403-33F, 2-inlet, 1-outlet, 3-way valve coupled with a VUA-2403-33F, 2-way, 3-position detented unit on a mounting base (MB-33-33). Versa valve assembly shall be a 3-position assembly with all 0.375-inch ports blocked in center position. Provide an escutcheon plate marked PURGE-OFF-NORMAL.

H. Air tubing shall be 0.375-inch polyethylene type HP plastic tubing for subplate assembly.

I. Air purge shall consist of a purge meter with a differential pressure regulator integrally piped. Purge meter shall be of rotameter type with a metering tube housed in a fiberglass body. Meter shall be equipped with brass end fittings, Buna-N O-rings, stainless steel needle valve in inlet fitting, and nylon ball check valve in outlet fitting. Metering tube shall be of snap-in type for easy removal for range change or cleaning. Tube shall have etched graduations for direct reading of flow rate. A constant differential pressure regulator shall be provided to maintain a constant flow rate with varying downstream pressure. Regulator shall have a brass body with Buna-N diaphragm and it shall be piped to purge meter with copper tubing. Regulator shall be designed for a maximum differential pressure of 100 psi.

J. Rotameter air capacity shall be 0.1-1 scfh, and pressure regulating valve shall regulate 0-30 psi with an input air rating of 150 psi.

2.04 SONIC LEVEL TRANSMITTER

A. Sonic level device shall be microprocessor-based and include sensing head, control cabinet, and cable between head and control cabinet.

B. Length of cable shall be sufficient for application shown.

C. Sensor shall automatically compensate for ambient temperature changes.

D. Contractor, equipment supplier, and manufacturer shall examine Drawings for each installation to properly apply equipment in each application.

E. Equipment supplier and Contractor must ensure beam angle of sensor shall not have interference from walls, pipes, or other objects at each location. Shop Drawings shall be specific about model numbers at each location, and detail sketches must show mounting height, zero dimensions, span dimensions, and beam angle data for each location.

F. Any device that will not function reliably to specifications in its application shall be replaced at Contractor's expense.

G. Sonic sensor head shall be intrinsically safe for NEMA 7 areas (explosion-proof) as applicable. Sensor head shall be epoxy-coated metal, encapsulated, plastic, or mylar for corrosion resistance depending upon the specific application. The equipment supplier shall select materials to provide corrosion resistance in the intended application. Sensor head and reflector shall contain a thermostatically controlled heater for outdoor application for units that require sensor head heater for operation down to -20 degrees F.

H. Sonic frequency shall be less than 45 kHz. Frequencies above this range will not be accepted.

I. Control cabinet shall be supplied rated NEMA 4X. Control cabinet shall contain a receiver processor, a full-hinged front door, a control cabinet thermostat controlled heater for -20 degrees F operation, and local digital indicator configured in engineering units.

J. Connections to controller and sonic sensor shall be with well-marked terminal blocks.

K. Field adjustments shall be made through membrane keypads. Units requiring the use of an oscilloscope will not be accepted.

L. Operational Data:

1. Temperature: Sensor to operate within specifications over -20 degrees F to 150 degrees F. Controller shall operate from 32 degrees F to 120 degrees F without heater, and to -20 degrees F with a heater.

2. Pulse Rate: 1.5 pps minimum sensing rate.

3. Operating Frequency: Less than 45 kHz.

4. Reflection Blocking: Adjustable receiver blanking to operate only on first pulse received.

5. Cable Length: Sensor and controller may be separated up to 500 feet.

6. AGC: Automatic gain control to maximize signal to noise ratio.

7. System Accuracy: Plus or minus 1.0 percent of full scale over the complete temperature range.

8. Power Supply: 120 volt AC plus or minus 10 percent at 60 Hertz with power consumption of 100 watts maximum exclusive of controller heaters.

9. Output: 4-20 mA output linear with level into 0-700 ohms. Output shall be isolated, floating to prevent system ground loops when used with other control loops that have an established common at a remote location. Output time constant shall be adjustable through keypad from 1 to 10 seconds.

10. Provide both level and flow outputs when specified in the Schedule included at the end of this Section.

2.05 LEVEL SENSOR SCHEDULE

A. A flow meter schedule is provided at the end of this Section.

PART 3 EXECUTION

3.01 GENERAL

A. Examination, Installation, Field Quality Control, Demonstration: In accordance with Section 40 91 00.

3.02 FIELD QUALITY CONTROL

A. Installation Check: The manufacturer shall provide the services of a factory-trained representative to check the installation of all equipment installed in this Section.

1. Satisfactorily calibrate each bubbler and sonic sensor and instruct the plant personnel in the operation and maintenance of each item.

B. Manufacturer's representative shall include a half-day of start-up service by a factory-trained technician for each bubbler and sonic sensor.

1. Contractor will schedule a date and time for start-up.

2. Contractor shall schedule the following people to be present during the start-up procedure.

a. Contractor
b. Company factory trained representative
c. Owner's personnel

LEVEL INSTRUMENT SCHEDULE		
Item Description/Location	**Supplier**	**Remarks**
Float Switches		
Raw Water Pump No. 1A Low Level Shutdown Float Switch/Raw Water Pump Chamber No. 1	Instrumentation Supplier	N/A
Raw Water Pump No. 2A Low Level Shutdown Float Switch/Raw Water Pump Chamber No. 2	Instrumentation Supplier	N/A
Raw Water Pump No. 3A Low Level Shutdown Float Switch/Raw Water Pump Chamber No. 3	Instrumentation Supplier	N/A
Alum Bulk Storage Area Leak Detection Float Switch No.1/Alum Bulk Storage Tank Area	Instrumentation Supplier	N/A
Alum Bulk Storage Area Leak Detection Float Switch No.2/Alum Bulk Storage Tank Area	Instrumentation Supplier	N/A
Alum Feed Area Leak Detection Float Switch/Alum Feed Area	Instrumentation Supplier	N/A
Sodium Hydroxide Bulk Storage Area Leak Detection Float Switch/Sodium Hydroxide Bulk Storage Tank Area	Instrumentation Supplier	N/A
Sodium Hydroxide Feed Area Leak Detection Float Switch/Sodium Hydroxide Feed Area	Instrumentation Supplier	N/A
Sodium Hypochlorite Bulk Storage Area Leak Detection Float Switch No.1/Sodium Hypochlorite Bulk Storage Tank Area	Instrumentation Supplier	N/A
Sodium Hypochlorite Bulk Storage Area Leak Detection Float Switch No.2/Sodium Hypochlorite Bulk Storage Tank Area	Instrumentation Supplier	N/A
Sodium Hypochlorite Feed Area Leak Detection Float Switch/Sodium Hypochlorite Feed Area	Instrumentation Supplier	N/A
Corrosion Inhibitor Bulk Storage Area Leak Detection Float Switch/Corrosion Inhibitor Bulk Storage Tank Area	Instrumentation Supplier	N/A
Corrosion Inhibitor Feed Area Leak Detection Float Switch/Corrosion Inhibitor Feed Area	Instrumentation Supplier	N/A
Fluoride Bulk Storage Area Leak Detection Float Switch/Fluoride Bulk Storage Tank Area	Instrumentation Supplier	N/A
Fluoride Feed Area Leak Detection Float Switch/Fluoride Feed Area	Instrumentation Supplier	N/A
Sodium Thiosulfate Low Level Float Switch/Sodium Thiosulfate Tote	Instrumentation Supplier	N/A
Filter Influent Channel High Level Float Switch/Filter Influent Channel	Instrumentation Supplier	N/A
Filter Gallery Pipe Trench Float Switch/Filter Gallery Pipe Trench	Instrumentation Supplier	N/A

LEVEL INSTRUMENT SCHEDULE (Continued)		
Item Description/Location	**Supplier**	**Remarks**
GAC Contactor Gallery Pipe Trench Float Switch/GAC Contactor Gallery Pipe Trench	Instrumentation Supplier	N/A
Elevated Backwash Water Storage Tank High Level Float Switch/Elevated Backwash Water Storage Tank	Instrumentation Supplier	N/A
Elevated Backwash Water Storage Tank High High Level Float Switch/Elevated Backwash Water Storage Tank	Instrumentation Supplier	N/A
Clearwell Low Level Float Switch/Clearwell	Instrumentation Supplier	N/A
Finished Water Pump Chamber Low Level Float Switch/Finished Water Pump Chamber	Instrumentation Supplier	N/A
Filtrate Pump Station "Pumps Off" Float Switch/Filtrate Pump Station	Instrumentation Supplier	N/A
Filtrate Pump Station "Lead Pump On" Float Switch/Filtrate Pump Station	Instrumentation Supplier	N/A
Filtrate Pump Station "Lag Pump On" Float Switch/Filtrate Pump Station	Instrumentation Supplier	N/A
Filtrate Pump Station "High Level Alarm" Float Switch/Filtrate Pump Station	Instrumentation Supplier	N/A
Bubbler Level Sensors (With Transmitters)		
Filter Influent Channel Level Sensor/Filter Influent Channel	Filter Equipment Supplier	N/A
Ultrasonic Level Sensors (With Transmitters)		
Raw Water Pump Chamber No. 1 Level Sensor/Raw Water Pump Chamber No. 1	System Integrator	N/A
Raw Water Pump Chamber No. 2 Level Sensor/Raw Water Pump Chamber No. 2	System Integrator	N/A
Raw Water Pump Chamber No. 3 Level Sensor/Raw Water Pump Chamber No. 3	System Integrator	N/A
Alum Bulk Storage Tank No. 1 Level Sensor/Alum Bulk Storage Tank No. 1	System Integrator	N/A
Alum Bulk Storage Tank No. 2 Level Sensor/Alum Storage Bulk Tank No. 2	System Integrator	N/A
Sodium Hydroxide Bulk Storage Tank Level Sensor/Sodium Hydroxide Bulk Storage Tank	System Integrator	N/A
Sodium Hypochlorite Bulk Storage Tank No. 1 Level Sensor/Sodium Hypochlorite Bulk Storage Tank No. 1	System Integrator	N/A

LEVEL INSTRUMENT SCHEDULE (Continued)		
Item Description/Location	**Supplier**	**Remarks**
Sodium Hypochlorite Bulk Storage Tank No. 2 Level Sensor/Sodium Hypochlorite Bulk Storage Tank No. 2	System Integrator	N/A
Corrosion Inhibitor Bulk Storage Tank Level Sensor/Corrosion Inhibitor Bulk Storage Tank	System Integrator	N/A
Fluoride Bulk Storage Tank Level Sensor/Fluoride Bulk Storage Tank	System Integrator	N/A
Filter No. 1 Level Sensor/Filter No.1	Filter Equipment Supplier	N/A
Filter No. 2 Level Sensor/Filter No. 2	Filter Equipment Supplier	N/A
Filter No. 3 Level Sensor/Filter No. 3	Filter Equipment Supplier	N/A
Filter No. 4 Level Sensor/Filter No. 4	Filter Equipment Supplier	N/A
GAC Contactor Gallery Influent Channel Level Sensor/GAC Contactor Influent Channel	GAC Contactor Equipment Supplier	Provide Flow Signal
Spent Backwash Water Storage Basin Level Sensor/Spent Backwash Water Storage Basin	System Integrator	N/A
Washwater Outfall Flow Measurement Structure Level Sensor/Washwater Outfall Flow Measurement Structure	System Integrator	Provide Flow Signal
Note: When a particular type of instrument is furnished by separate suppliers the instruments shall be products of the same manufacturer to provide standardization.		

END OF SECTION

SECTION 40 94 00
PROGRAMMABLE LOGIC CONTROLLERS

PART 1 - GENERAL

1.1 GENERAL

A. The Contractor, through the use of the Instrumentation Supplier and qualified electrical installers, shall provide and install the programmable logic controller-based control system (PLCS) hardware complete and operable, in accordance with the Drawings and Specifications.

B. Instrumentation Supplier: It is the intent of these Specifications to have the Instrumentation Supplier singularly responsible for selecting and verifying correct and compatible hardware to provide a functional PLCS and for supplying such equipment. The Instrumentation Supplier must also be capable of providing future support of all PLCS hardware.

C. Minimum Instrumentation Supplier Scope: The exact relationship between the Contractor and Instrumentation Supplier cannot be fully defined; however, the basic scope of services for the Instrumentation Supplier is defined in Section 40 91 00. Other Sections related to field instruments further define the Instrumentation Supplier's scope.

1.2 ACTION SUBMITTALS

A. Shop Drawings: PLCS hardware submittals shall be in accordance with the applicable requirements of Section 40 91 00 – Process Control and Instrumentation Systems. PLCS submittals shall, however, be made separately from other process control and instrumentation system submittals.

B. Hardware Submittals: The PLCS hardware submittal shall be a single submittal which includes at least the following:

1. A complete index appearing in the front of each bound submittal volume. System groups shall be separated by labeled tags.

2. Complete grounding requirements for the entire PLCS, including any requirements for PLCS communication networks and electrical equipment.

3. Data sheets shall be included for each PLCS component together with a technical product brochure or bulletin. These data sheets shall show the component name as used within the Contract Documents, the manufacturer's model number or other identifying product designation, the

project tag number, the project system of which it is a part, the Site to which it applies, the input and output characteristics, the requirements for electric power, the ambient operating condition requirements, and details on materials of construction.

4. A bill of material list, including quantity, description, manufacturer, and part number, shall be submitted for each component of the PLCS system. Bills of material shall include all items within an enclosure.

C. Factory Test Procedure: The Instrumentation Supplier shall prepare and submit a factory test procedure which incorporates test sequences, test forms, samples of database lists, a PLCS testing block diagram, and an estimated test duration which complies with the requirements of the factory test specified herein.

1.3 CLOSEOUT SUBMITTALS

A. Submit warranties and bonds in accordance with Section 01 74 00.

B. Submit operation and maintenance data in accordance with Section 01 78 23.

1.4 STORAGE AND HANDLING

A. All equipment and materials delivered to the Site shall be stored in a location that is suitable to ensure the integrity of the equipment in accordance with the manufacturer's recommendations. Storage and handling shall be performed in a manner that shall afford maximum protection to the equipment and materials. It is the Contractor's responsibility to assure proper handling and on-site storage.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. The requirements of Section 40 91 00 – Process Control and Instrumentation Systems apply to this Section.

B. All materials and all PLCS equipment furnished under this Contract shall be new, free from defects, of first quality, and produced by manufacturers regularly engaged in the manufacture of these products.

C. Hardware Commonality: Where there is more than one item of similar equipment being furnished all such similar equipment shall be the product of a singular manufacturer.

2.2 PLC ENCLOSURE

A. Each PLC and its corresponding I/O modules, power supply module(s), communication interface device(s), and peripheral equipment shall be mounted

inside suitable enclosures as required by Section 40 95 13 Process Control Panels and Hardware. All I/O wiring from the field to the I/O modules shall be terminated on terminal blocks in the enclosure.

2.3 UNINTERRUPTIBLE POWER SUPPLY

A. Provide DIN rail mounted UPS power supplies as shown on the Drawings.

2.4 PROGRAMMABLE LOGIC CONTROLLERS (PLC)

A. General: Each controller shall be supplied with the CPU, communication cards, inputs, outputs, communications adapters, power supply, and all power and interface cables necessary to function as a complete and operable programmable logic controller (PLC) system as shown on the Drawings and specified herein.

B. Provide Siemens Simatic equipment as listed below or Siemens recommended direct replacement for obsolete part numbers:

1. Central Processing Unit (CPU): S7-1500, CPU 1516F-3 PN/DP.
2. Digital Input Module: S7-1500/ET 200MP, DI 16x24 VDC HF
3. Digital Output Module: S7-1500/ET 200MP, DQ 16x24VDC/0.5A ST
4. Analog Input Module: S7-1500/ET 200MP, AI 8xU/I/RTD/TC ST
5. Analog Output Module: S7-1500/ET 200MP, A 8xU/I HS

C. Remote IO shall utilize the ET 200MP platform and cards listed above.

D. Provide spare primary control units WTP-LCP-1 and RWI-LCP-1with the final programming installed for storage on the shelf to be direct plug and play replacements to the installed units.

2.5 NETWORK HARDWARE

A. Provide all unshielded twisted pair cabling in compliance with EIA/TIA 568 Category 6 listed for use in plenum spaces.

B. Network switches shall be Siemens Scalance XR552-12M series, with all appropriate cards to complete network. Contractor shall provide 20% spare available ports (installed and ready for connection).

2.6 SPARE PARTS

A. Provide the following Siemens equipment spares:

1. Processor
2. Power Supply
3. DI module
4. DO module
5. AI module

6. AO module
7. Profibus Bridge
8. Fiber converters one of each type used.

2.7 SOFTWARE LICENSING

A. Provide the following software packages with hardware keys. Contractor shall coordinate with Owner to register the software to the Owner.

1. Latest version of the SIMATIC STEP 7 Professional (TIA Portal) software

PART 3 - EXECUTION

3.1 INSTALLATION

A. The Contractor shall utilize qualified personnel to accomplish, or supervise the physical installation of all elements, components, accessories, or assemblies provided. The Contractor shall employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies it provides.

B. PLC Panel Configuration: The PLC panel configurations and layouts shall be as shown on the approved Shop Drawings, no exceptions. Clear space is to be provided above and below PLC equipment racks in accordance with Siemens guidelines.

C. All components of the PLCS, including all communication cabling, shall be the installation responsibility of the Contractor unless specifically noted otherwise. The installation of the communication network shall be the complete installation responsibility of the Contractor, including all cables, connectors, transceivers, antennas, and any required electrical grounds. Grounding shall be shown on Shop Drawings. After installation of the PLCS is completed, the installation shall be inspected jointly by the Contractor and the Instrumentation Supplier. Any problems shall be corrected, and when both are satisfied with the installation, a written certification of the installation shall be delivered to the Engineer. The certification shall state that all PLC communication and I/O modules, modems, system grounds, communication network, and all other components of the PLCS have been inspected and are installed in accordance with the manufacturer's guidelines.

D. All Profinet and Profibus cabling shall be done in accordance with Siemens Planning and Installation Manuals and in accordance with Profibus and Profinet International (PI).

3.2 FACTORY TEST

A. General: Prior to shipment of the PLCS from the factory, but after the procurement, assembly, and configuration of all components, the Instrumentation Supplier shall conduct a factory test. This test may be witnessed by a representative of the Owner and the Engineer. No PLCS shall be shipped without the Engineer's written approval of the factory test. The factory test is intended to address a complete PLCS. The factory test shall demonstrate the functionality and performance of specified features of each PLC. The test shall include verification of all PLCs, and remote I/O system I/O points. Each point shall be checked from the terminal strip to register in the PLC processor. A complete system checklist shall be available during the test for recording results of selected points. A minimum of ten (10) working days' notification shall be provided to the Engineer prior to testing. Additional factory testing requirements are set forth in Section 40 96 35

B. Test Setup: The complete PLCS shall be assembled and interconnected on the Instrumentation Supplier's factory floor. The PLCs and communication devices shall be loaded with their applicable software packages. PLC input and output modules shall be installed in their assigned housings and wired to field termination points in the enclosures.

C. The Contractor shall schedule one (1) factory test after receiving approval of the factory test procedures submittal. One test shall be conducted for the complete system.

D. Test Procedure: The factory test shall be conducted in accordance with the previously submitted and approved test procedures.

E. Test Report: The Instrumentation Supplier shall record the results of all factory testing on preapproved test forms which the Owner's and Engineer's representatives shall sign. A copy of the completed test forms and a report certifying the results shall be provided to the Engineer within 10 days of completing the test.

F. Rework and Retest: If the PLCS does not operate as required, the Instrumentation Supplier shall make whatever corrections are necessary, and the failed parts of the tests shall be repeated. If, in the opinion of Engineer's representative, the changes made by the Instrumentation Supplier are sufficient in kind or scope to affect parts of system operation already tested, then the affected parts shall be retested also. If a reliable determination of the effect of changes made by the Instrumentation Supplier cannot be made, the Engineer's representative may require that all operations be retested. The Contractor and Instrumentation Supplier shall bear costs for the factory test, including any required retesting.

3.3 CALIBRATION, TESTING, AND INSTALLATION

A. Calibration: All analog inputs and outputs of the PLC shall have their calibration checked at a minimum of two (2) points to verify consistency with the balance of the analog loop. This calibration check shall be done in conjunction with the analog loop tests in Section 40 91 00 – Process Control and Instrumentation Systems. Operator interfaces and PLC registers shall both be verified for correctness.

B. The Contractor shall submit to the Engineer a system testing completion report when each process system and all aspects of the configuration software have been successfully tested as described herein. The report shall note any problems encountered and what action was required to correct them. It shall include a clear and unequivocal statement that the process systems have been thoroughly tested and are complete and functional in accordance with all Drawing and Specification requirements.

END OF SECTION

SECTION 40 94 13
DIGITAL PROCESS CONTROL COMPUTERS

PART 1 GENERAL

1.01 SUMMARY

A. This Section covers requirements for the computer subsystem (CS). Equipment, software, programming, and other components necessary to provide a complete functioning system shall be provided by the Instrumentation Supplier as defined in Section 40 91 00.

B. CS functions include successful communication with other equipment to allow the Owner to provide data acquisition, historical data storage, text and graphic data display, alarming, process control, data analysis, report generation, and program development. Requirements listed below identify minimum acceptable system performance. Provide all hardware and software packages required to make system totally operational. Provide turnkey startup assistance to the Owner during the Owner's applications software testing.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this Section:

1. Institute of Electrical and Electronics Engineers (IEEE): 802.3, Local Area Networks: Carrier Sense Multiple Access with Collision Detection
2. International Organization for Standardization (ISO): 7185, Programming Languages - PASCAL (Endorsement of British Standard BS 6192).

1.03 DEFINITIONS

A. Abbreviations:

1. CPU: Central Processing Unit.
2. CS: Computer Subsystem.
3. DCS: Distributed Control Subsystem.
4. DCU: Distributed Control Unit.
5. PLC: Programmable Logic Controller.
6. PMCS: Process Monitoring and Control Software.
7. RTU: Remote Terminal Unit.
8. TS: Telemetry Subsystem.

B. Terms:

1. Circular Files: Files that are updated such that each record written to file replaces oldest record in file.
2. Log a Message: Print a message on an alarm/status printer.
3. Field Interface Units, PLCs. If PLCs are used as RTUs, then requirements for PLCs also apply to RTUs.

C. Types of Variables:

1. Field Interface Unit Variables: Analog inputs, discrete inputs, analog outputs, discrete outputs, pulse inputs, calculated variables, and internal register values.
2. Calculated Analog Points (CA): Analog variables computed from inputs from field interface units, manual inputs, calculated discrete points, and other calculated analog points.
3. Process Variables (PV): Analog variables from field interface units and calculated analog points.

1.04 SUBMITTALS

A. Provide the following Shop Drawings and Submittals in accordance with Section 01 33 00 – Submittal Procedures:

1. CS block diagram and overview description. Include network IP addresses.
2. Bill of Materials for CS Components: Component number, manufacturer, model number, component description, and quantity.
3. Room Layout Drawings: Show to scale enclosures, furniture requirements, CS equipment, and service area requirements.
4. Power Connection Diagram: For CS equipment, show interconnection from power sources through uninterruptible power supplies and power distribution panels to computer and peripherals.
5. Grounding Diagram: For CS equipment, show grounding philosophy and implementation.
6. Interconnecting Wiring and Cabling Diagrams: For CS equipment, identify terminal receptacles, cable ID tags, actual cable lengths, and maximum distance limitations between cabinets or components.
7. Component Submittal: For each CS component:
    a. General data and description.
    b. Engineering Specifications and data sheets.
    c. Scaled drawings and mounting arrangements.
    d. Network equipment rack layouts.
    e. Description of software installed on each workstation or server.
    f. Equipment weights.
    g. Power and grounding requirements.
    h. External electrical interconnection and interface definitions.

8. Shop Drawings for Specifically Manufactured CS Equipment:
   a. A complete connection diagram.
   b. Data sheets on each major item: annotated as necessary to describe specific items furnished.
   c. Scaled layout and fabrication drawings.
      1) Cable access areas and cable routing.
      2) Power termination and ground lug location.
      3) Data cable termination points.
      4) Anchor bolt size and location.
   d. Installation and and mounting detail drawings.
   e. Equipment weights.
9. Power Consumption and Heat Dissipation Summary for CS Equipment: Voltages, current, phase(s), and maximum heat dissipations in Btu/hr.

B. Software:

1. Standard Software Documentation:

   a. System Software Documentation: Complete reference information for system users. Detailed descriptions including features and limitations of package, how to use package, and how package interfaces with other software packages.
      1) Extended Documentation for Operating System and Utilities:
         a) Base Documentation: For day-to-day users of tasks, including editing files and using command procedures.
         b) General User Documentation:
            (1) Index to Extended Documentation.
            (2) Using files, directories, command language, and text editors.
            (3) Alphabetic list of errors, warning, and informational messages, including explanation and response required.
         c) System Manager Documentation:
            (1) Setting up systems.
            (2) Maintaining system and files.
            (3) Optimizing performance.
            (4) Networking features.
         d) Programming Documentation:
            (1) Linking, loading, running, and debugging tasks.
            (2) Screen management.
            (3) Librarian and file management.
            (4) Device support and device drivers.
         e) Release notes.

2) Programming Language: Syntax, execution, use and reference capabilities.
3) Online and Offline Diagnostics: How they are used, and various execution options available.

b. PMCS: Detailed technical reference manuals and user level manuals.
1) Types of Manuals:
a) System Manager Documentation:
(1) Initial system setup.
(2) Database and file structures.
(3) Communication with field interface units.
(4) Maintaining system and files.
(5) Troubleshooting system problems.
(6) Optimizing performance.
b) System Engineer Documentation: Configuring, applications software.
c) Operator Documentation: Using the PMCS with configured applications software.
2) PMCS Functions:
a) Process database.
b) Communication with field devices.
c) Input processing.
d) Message logging.
e) CS diagnostic alarms.
f) Alarm handling.
g) Control processor.
h) Restart program.
i) Human-machine interface-general functions.
j) Graphics display generator.
k) Types of displays.
l) Alarm/Status log history.
m) Historical data collection.
n) Data retrieval.
o) Trending.
p) Report generator.

c. Disk and Memory Requirements: Table showing CPU and disk memory requirements for each standard software package.

d. Changes to Standard Software: If changes to standard software packages are needed to meet Specifications, provide detailed descriptions of proposed changes and additions.

e. Pre-Software Development Submittal: Provide software system overview to include written overview description of each major software package.

f. Disk and Memory Allocations: Tables showing breakdown of relative percentages of CPU and disk memory required, including spare.

C. Informational Submittals:

1. Testing related submittals.
2. O&M Manuals-Hardware:
   a. Updated version of hardware Shop Drawings.
   b. Component Manufacturers' O&M Manuals: Instructions for installation, operation, maintenance, troubleshooting, and calibration.
   c. List of spare parts and expendables provided.
   d. List of recommended additional spare parts.

3. O&M Manuals-Software Documentation:

   a. Updated version of Software Shop Drawings.
   b. Third Party Software: Include manufacturer's original disks and manuals with hardware shipments.

1.05 EXTRA MATERIALS

A. Spare Parts

1. Two (2) track balls of each type supplied.
2. One (1) keyboard of each type used for operator interface units.

B. Expendables:

1. Two (2) boxes (5,000 sheets per box), 20-pound, white paper for each laser printer.
2. One (1) toner cartridge kit and one (1) user maintenance kit for laser printer.
3. Ten (10) tape cartridges for computers using tape cartridges, including personal computers.
4. Fifty (50) compact disks for each computer using compact disks, including personal computers.
5. Twenty (20) percent, but no less than 10 of each type and current rating of fuse used.

PART 2 PRODUCTS

2.01 SYSTEM PERFORMANCE

A. Capacity:

1. Furnish CS with sufficient capacity to handle equipment required by Contract Documents and equipment listed under paragraph "Future Components", and still have specified spare capacity. Except for software configuring, implementing listed future components, shall not require addition of other CS hardware or software.
2. Spare capacities are based on size of CS as required to implement equipment required by Contract Documents plus equipment listed under paragraph "Future Components". For example, total storage capacity furnished for given functions:

   (CURRENT + FUTURE) * (100 + SPARE)/100

   Where:

   CURRENT Equals: Storage capacity required to implement that function for hardware and software furnished under Contract Documents.

   FUTURE Equals: Storage capacity required to implement that function for equipment listed under paragraph "Future Components".

   SPARE Equals: Percentage spare specified for that function.

3. Capacity refers to required physical size, storage capacity, and processing throughput of CS hardware and software. CS changes required to implement listed future components shall be limited to "configuring" database tables and system parameters to allow system to recognize the additional equipment.
4. In order to verify that system has required capacity, accelerate PLC polling rate and exception reporting rates during all tests to simulate inputs from additional devices listed under paragraph "Future Components". For example, if number of future RTUs listed equals the number of RTUs required by Contract Documents, conduct tests using a polling rate that is twice that specified.

B. Future Components: Furnish sufficient CS capacity to implement the following future components. Assume that each future field interface unit has a number of I/O points equal to average number of I/O points provided for similar units required by Contract Documents.

1. PLCs: 2.
2. CS Operator Interfaces: 1

2.02 SYSTEM SOFTWARE

A. Operating System:

1. Each workstation shall be provided with Microsoft's Windows 7 Professional operating system.
2. Each server shall be provided with Microsoft's Windows Server 2012 operating system.

B. Utilities:

1. File Management:

    a. General-purpose file system supporting dynamic creation, extension, and deletion of disk files from source programs, object programs, and data files.
    b. Copy individual files between devices (e.g., disk to disk, disk to tape, tape to disk, and disk to printer).
2. Network Communications: General-purpose network communications software to support local area network connection between CS and personal computers. Software must allow for exchange of disk files between computer systems.
3. Disk Backup and Reload: Operator-initiated utility for maintaining backup copy on removable disk pack of all CS disk files. Floppy diskettes are not acceptable for backup.

C. Diagnostics:

1. Online Diagnostics:
    a. Complete system of diagnostic software to monitor, isolate, identify, tabulate, and alarm system hardware malfunctions and software failures.
        1) Input/output addressing for all I/O devices (detection of illegal addresses).
        2) Incorrect data transfers (e.g., parity error).
        3) No response (or time-out) from I/O device.
    b. Central mechanism for accumulating and reporting number of soft and hard system errors. Hard errors are errors that persist after multiple retries.
2. Offline Diagnostics: Exercise and identify problems for all CS equipment.

2.03 PROCESS MONITORING AND CONTROL SOFTWARE (PMCS) PACKAGE

A. General: The PMCS application software shall be Wonderware's Intouch 2014 with 60,000 I/O. The system shall include a Historian for 5000 I/O points, the Historian Client software with client access licenses. Provide the two (2) years of Wonderware's "Comprehensive Annual Support". The support agreement shall begin once the installed software has been delivered to and accepted by the Owner.

B. PMCS HMI Development Workstation Software:

1. Provide Wonderware's Intouch Devolopment Studio Unlimited Unlim/60K/500 2014 software.
2. The software shall allow the graphic displays to be viewed from any of the workstations on the wired Ethernet network.

C. PMCS HMI View Workstation Software:

1. Provide Wonderware's Intouch 2014 Runtime 60K with I/O
2. The software shall allow the graphic displays to be viewed from any of the workstations on the wired Ethernet network.

D. PMCS Historical Data Storage and Retrieval Application Software:

1. Provide Wonderware's Historian 2014 Standard software, 5000 Tags.
2. Provide Wonderware's Historian Client Per Server Concurrent, 10 Users.
3. Provide Wonderware CAL with MS Cal Runtime, 10 Pack, SQL 2012 Standard
4. The software shall be installed to allow designated variables to be saved for trending, report generation, and historical records. In addition, the software package shall allow data to be retrieved for listing, trending, reporting, and input to other programs from disk or tape.

E. PMCS Reporting Application Software:

1. Provide the latest Hach WIMS software and SCADA connector.
2. The software shall allow the viewing and printing of historical data.

F. PMCS Alarm Notification Application Software:

1. Provide WIN-911 Enterprise alarm notification software.
2. Provide WIN-911 Premium Voice option
3. Provide a MultiTech external USB TAPI compliant voice modem for single voice line connection

4. The software shall be capable of delivering voice, email, and mobile alerts to telephone-related or email devices for alerts generated from alarms or other specified conditions.

G. Restart Program:

1. At least every 5 minutes, save on disk, CPU memory resident data needed to completely characterize current status of CS hardware and software.
2. When system restart is required, use saved data to initialize CPU memory resident data. Use battery operated clock to set time and date. Execute "housekeeping" required to restore system to normal operation.

2.04 HARDWARE

A. CS Block Diagram: Refer to figure CS Block Diagram on Drawings. Interconnecting lines shown on block diagram imply information flow and not necessarily wiring.

B. Control Room Layout: Refer to Drawings.

C. Equipment Mounting: Unless otherwise noted, mount all CS components in freestanding metal cabinets or provide with suitable metal stands to bring them to normal operating levels.

D. Color: Color-coordinate CS components to produce an attractive installation.

E. Cables Required:

1. Provide interconnection between all CS components, except where leased telephone lines are shown.
2. Cables Under 50 Feet Long: Prefabricated with connectors and factory tested with CS.
3. Provide special signal conditioning/repeating equipment as required for proper operation of CS.
4. Surge Arrestors: Provide for connections to CS from equipment outside control room. Also, provide to protect CS from damage by electrical transients induced in cables by lighting discharges or electrical equipment.

F. Power to CS Equipment:

1. Control Room: Uninterruptible power supply system.
2. Other Locations: 120-volt ac, single-phase, three-wire, 60 Hertx.

G. Power Failure Detection and AUTO Restart:

1. Prevents errors due to power failure or short-term power fluctuations that occur when UPS is not operating.
2. Power Failure: Voltage variations in excess of plus or minus 10 percent of normal for a duration of 0.5 second or longer shall cause CS equipment to automatically shut down as required to prevent introducing errors on disk.
3. Short-Term Power Fluctuations: Voltage variations in excess of plus or minus 10 percent of normal for durations of 0.001 to 0.5 second shall result in CS shutdown as above or buffering must be provided to prevent fluctuations from causing errors.
4. CS shall execute restart program and return to normal operation when power is restored. Battery backed-up real-time clock shall be used by CS during automatic restart to set time and date.

2.05 EQUIPMENT

A. CS Component List Format:

1. Quantity: Capacities and quantities shown are minimums. Provide additional capacity or units as necessary to meet the functional requirements. Refer to Drawings where no quantity is listed here.
2. Component Identification Code: Refer to Drawings for general component identification.

B. CS Component List:

1. Historian Server

a. General:
   1) Note: Components specified herein are based on the state of the art during design. Instrumentation Supplier shall provide the latest state of the art hardware available during the submittal process, and shall upgrade features as necessary. The following specifications outline minimum requirements for each computer.
   2) Function: Support LAN clients; execute required HMI server software; operator interface to LAN; provides server services to client HMI nodes on LAN
   3) Type: 100 percent IBM Compatible.
   4) Quantity: 1.

b. Features:
   1) Intel Xeon E5-2407 processor, 2.2GHz, w/10 MB Cache
   2) 8 GB Single Rank RDIMM, 1600 MHz.
   3) RAID 5 for H710/H310 (3-8 HDDs)
   4) Four (4) 300 GB 10K rpm SAS 6 Gbps 2.5 inch hot-plug hard drives
   5) Dual embedded gigabit Ethernet card.

6) Internal PowerVault 110T, LTO2-L Tape Backup, 200/400 GB, with controller.
7) 48X IDE CD-RW/DVD-ROM drive.
8) Redundant Hot-Plug power supply.
9) Ports: 3 USB, 1 audio, 1 keyboard, 1 mouse, 1 video.
10) Standard Windows keyboard with USB.
11) Standard system mouse.
12) Rack chassis with sliding Rapid/Versa rails.

c. Software:
1) Microsoft Windows Server 2012 Standard Edition x64
3) Symantec anti-virus software, latest version.
4) Microsoft Office Professional, latest version compatible with installed operating system.

d. Support Agreement:
1) Hardware Phone Support: 7 day/24 hour, lifetime.
2) Hardware Support: 7 day/24 hour, 4-hour response, 5 years.

e. Manufacturer and Product:
1) Dell PowerEdge Server.
2) Equivalent HP Server.

2. Operator Workstation:

a. General:
1) Note: Components specified herein are based on the state of the art during design. Instrumentation Supplier shall provide the latest state of the art hardware available during the submittal process, and shall upgrade features as necessary. The following specifications outline minimum requirements for each computer.
2) Function: Support LAN clients; execute required HMI software; operator interface to LAN.
3) Type: 100 percent IBM compatible.
4) Quantity: 2

b. Features:
1) Dual Monitors: 23-inch LED.
2) Intel® Xeon® Processor E3-1225 v3 (Quad Core, 3.20 GHz Turbo, 8 MB)
3) 8 GB (2x4GB) 1600 MHz DDR3 non-ECC
4) 500 GB 3.5-inch serial ATA (7200 rpm) hard drive
5) 1 GB Integrated NIC.
6) 16x DVD+/-RW drive
7) 1 GB AMD FirePro™ V4900 (2DP & 1DVI-I) (2DP-DVI & 1DVI-VGA adapter)
9) Ports: 5 USB, 1 audio, 2 video.
9) Standard Windows USB keyboard.
10) Standard System USB scroll mouse.

11) Integrated 7.1 Channel audio sound card.
12) Dell USB SoundBar.

c. Software:
1) Microsoft Windows 7 Professional x64.
2) CD-RW/DVD-RW
3) Symantec anti-virus software, latest version.
4) Microsoft Office Professional, latest version.
5) Resource DVD

d. Support Agreement:
1) Onsite Hardware Support: 7 day/24 hour, 4-hour response, 5 years.

e. Manufacturer and Product:
1) Dell Precision Workstation.
2) Equivalent HP Computer.

3. Development Workstation:

a. General:
1) Note: Components specified herein are based on the state of the art during design. Instrumentation Supplier shall provide the latest state of the art hardware available during the submittal process, and shall upgrade features as necessary. The following specifications outline minimum requirements for each computer.
2) Function: Support LAN clients; execute required HMI software; operator interface to LAN; provide developer with access for testing, upgrades and support.
3) Type: 100 percent IBM compatible.
4) Quantity: 1

b. Features:
1) Dual Monitors: 23-inch LED.
2) Intel® Xeon® Processor E3-1225 v3 (Quad Core, 3.20 GHz Turbo, 8 MB)
3) 8 GB (2x4GB) 1600 MHz DDR3 non-ECC
4) 500 GB 3.5-inch serial ATA (7200 rpm) Hard Drive
5) 1 GB Integrated NIC.
6) 16x DVD+/-RW drive
7) 1 GB AMD FirePro™ V4900 (2DP & 1DVI-I) (2DP-DVI & 1DVI-VGA adapter)
9) Ports: 5 USB, 1 audio, 2 video.
9) Standard Windows USB keyboard.
10) Standard System USB scroll mouse.
11) Integrated 7.1 Channel audio sound card.
12) Dell USB SoundBar.

c. Software:
1) Microsoft Windows 7 Professional x64.

2) CD-RW/DVD-RW
3) Symantec anti-virus software, latest version.
4) Microsoft Office Professional, latest version.
5) Resource DVD

d. Support Agreement:
1) Onsite Hardware Support: 7 day/24 hour, 4-hour response, 5 years.

e. Manufacturer and Product:
1) Dell Precision Workstation.
2) Equivalent HP Computer.

4. Printer, Laser:

a. General:
1) Function: Allow report and graphic display printing.
2) Quantity: 1
3) Configure workstations for the project to print to this printer as the default printer.
4) Setup: Complete with software, switch settings, and other facilities required for proper operation when connected to IBM compatible desktop computer.

b. Features:
1) Standard Size Paper Trays: Letter, executive, and tabloid.
2) Print Speed: Minimum 35 pages per minute per plain text.
3) Printing Volume: Maximum volume not less than 95,000 pages per month.

c. Signal Interface/Cables Fast Ethernet: 101100 Base-TX connection for direct connection to 803.3 (Ethernet) network; suitable Category 6 cable with minimum length based on equipment placement.

d. Memory: 1152 MB memory, unless otherwise noted.

e. Power: 120 Vac, 60 Hz, with power cord of 6-foot minimum length.

f. Toner Cartridges: One (1) in printer plus one (1) spare in sealed packaging.

g. Options:
1) Internal Print Server.
2) Additional Expansion Ports.
3) Internal Hard Drive.
4) Capable of Duplex Printing.

h. Manufacturers:
1) Dell.
2) Hewlett-Packard.

5. Displays for Outside SCADA Network:

   a. General:
      1) 48" Diagonal viewing area
      2) Color: 1200:1 contrast ratio
      3) LED or LCD
      4) 120VAC Power
   b. Quantity: 3

6. LAN Switch, Stackable, 101100 Mbps:

   a. General:
      1) Functions: Interconnects Ethernet nodes at OSI Level 2. Improves LAN performance over traditional hub interconnecting. Provides data traffic filtering.
      2) Type:
         a) Auto negotiating 10110011000 Mbps copper ports.
         b) 64-Gbps high speed stackwise plus stacking.
         c) Parts: Control Switch; Member Switch(es).
   b. Features:
      1) Field-replaceable power supply and fan tray.
      2) One (1) rack unit fixed configuration.
      3) Provides full IPv4 dynamic routing.
      4) Indicators:
         a) Per port Status LEDs: Link integrity, disabled, activity, speed, and full duplex.
         b) System Status LEDs: System, RPS, and bandwidth utilization.
      5) Connectors: RJ-45.
      6) Member Switches: One (1), unless otherwise noted.
      7) 10110011000 Mbps Ports: 24; unless otherwise noted.
   c. Power: 90-1351180-264 VAC, 47-63 Hz, autosensing.
   d. Nominal Dimensions (H x W x D, inches): 2 x 18 x 18.
   e. Manufacturer and Product:
      1) Cisco, Catalyst 3750E-24TD-E Stackable Switch.

PART 3 EXECUTION

3.01 INSTALLATIONQUALITY CONTROL, TESTING, AND TRAINING

A. Install equipment in accordance with the manufacturer's recommendations.

B. Detailed system testing requirement are included in Section 40 96 35.

END OF SECTION

SECTION 40 95 13
PROCESS CONTROL PANELS AND HARDWARE

PART 1 GENERAL

1.01 SUMMARY

A. This Section applies to fabricated process control panels and hardware that are not part of an equipment supplier's pre-packaged and pre-engineered control system. Panels provided under this Section shall be supplied by the Instrumentation Supplier as defined in Section 40 91 00. Pre-engineered controls shall comply with Section 40 99 90.

B. Section Includes:

1. Control panels and consoles.
2. Switches, push-buttons, lights.
3. Relays.
4. Timing devices.
5. Terminal blocks.
6. Control power transformers.

1.02 SUBMITTALS

A. Shop Drawings: Submit Shop Drawings in accordance with Specification Section 01 33 00.

B. Control panel drawings shall include at a minimum:

1. Title page
2. Drawing index
3. Power one-line
4. Power wiring (with CB and fuse type and size)
5. Panel layout with bill of material
6. PLC rack layout
7. Individual card layouts, indicating wiring to each device and scale of analog/digital signals
8. Terminal rotation
9. Dip switch, or jumper settings
10. Riser diagram or interconnection diagram
11. All drawings shall include wire numbers, type and size for wiring
12. Loop drawings (meeting ISA 5.4 standards)
13. Panel elevation
14. Panel door tagging and components

1.03 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Codes, Ordinances, and Industrial Standards: Design, testing, assembly, and methods of installation for materials, electrical equipment, and accessories provided under this Section shall conform to the National Electric Code and to applicable State and local requirements.
2. UL listing and labeling of custom-built panels (UL 508) shall be adhered to under this Contract. All panels shall be fabricated by a UL panel shop and have a UL 508 label attached.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with specified requirements, manufacturers offering products which may be incorporated in Work include:

1. Switches, Push-Buttons, Lights:
   a. Allen-Bradley (Type 800T/H LED).
2. Relays:
   a. Allen-Bradley (Type 700-HA, or 700-P).
   b. Square D Co.
   c. Omron
   d. Phoenix Contact
3. Latching Relays:
   a. Allen-Bradley (Type 700-PL).
   b. Potter-Brumfield
   c. Struthers-Dunn
   d. Phoenix Contact
4. Programmable Timers:
   a. Allen-Bradley (Type 700-HR)
5. Terminal Blocks:
   a. Allen-Bradley
   b. Altech
   c. GE Consumer & Industrial
   d. Square D Co.
   e. Thomas & Betts
   f. Weidmueller
   g. Phoenix Contact
6. Fusible Terminal Blocks:
   a. Allen-Bradley
   b. Altech

c. Square D Co.
d. Weidmueller
e. Phoenix Contact

7. Control Power Transformers:
   a. Allen-Bradley
   b. Sola
   c. Phoenix Contact
8. Textured Polyurethane Enamel:
   a. Sherwin-Williams, Polane T and/or Polane HST.
9. Wire Markers:
   a. Brady
   b. T&B
   c. Westline
   d. Panduit

2.02 CONTROL PANELS AND CONSOLES

A. Sheet Metal Construction:

1. Panels and consoles shall be fabricated from sheet steel welded and bolted into a rigid self-supporting structure a maximum of 90 inches high and a minimum of 20 inches deep. Overall length shall be coordinated with space requirements available where the panel is intended to be used. Refer to plans for unit location and available space and coordinate size accordingly. Panel face layouts shown on Drawings are intended to indicate relative position of all components. Instrumentation Supplier shall fix exact locations and overall dimensions to meet requirements of its equipment.
2. Panel and console bodies shall be a minimum of 12 gauge steel for panels up to 42 inches in width, and 10 gauge minimum steel for panels exceeding 42 inches in width. Panel subplates shall be same gauge as enclosure. Stiffening members shall be provided for strength and stiffness as required.
3. A minimum of 3 inches shall be provided between edge of panel subplate and outside walls of panel body to ensure adequate wire-way space for external wires entering panel. Panel subplate shall be mounted on collar studs for easy removal. Print pockets shall be provided on each panel. Brackets welded to inside of panel, complete with lights, shall be provided on panels where indicated by Drawings.
4. Identification plates shall be laminated phenolic with white letters engraved on a black background and mounted with screws or double-back adhesive foam tape.
5. All components inside panel shall have identification plates. This includes instruments, relays, switches, circuit boards in plug-in racks, etc. Identification plates shall include engineering symbols (FBQ-1, SW-3, FIC-4, CR-1, etc.). Switches and circuit breakers inside panel shall have names (Horn, Audio Tone, Panel Power, etc.) on identification plates as well as engineering symbol.

6. Identification plates shall be located on or adjacent to device they are identifying and shall be readable without looking around, under, or on top of device to find identification plate.

B. Access:

1. Wall- and/or floor-mounted control panels shall have continuous piano-hinged doors for ease of access. Door openings shall expose a minimum of 80 percent of panel interior. Door openings shall be sealed with a 0.125-inch thick minimum cellular neoprene gasket cemented with oil-resistant adhesive and held in place with a retaining strip. Print pockets shall be provided on each door. Two-door enclosures shall have a removable center post. Panel doors less than 40 inches high shall be equipped with a 2-point latching mechanism. Panel doors 40 inches high or more shall be equipped with a 3-point latching mechanism.
2. Components and terminals shall be accessible without removing another component except covers. Swing out sections shall be used if mounting space is required that is not normally accessible.
3. Panels shall have open bottoms except where structural members are required.

C. Finish:

1. Panel face openings for mounting equipment shall be smoothly finished cut with counterboring and trim strips provided as required to give a neat finished appearance. Bezels shall be used on all front panel-mounted devices to cover panel cutouts. A chrome-plated or stainless steel bezel shall be used at parting line of panels that have shipping splits or at parting line of panels placed end to end.
2. Graphic plates, when used, shall be fastened to panel frame with fasteners not visible from front of graphic.
3. After fabrication, panel surfaces shall be given a phosphatizing treatment inside and out, and then finished with 2 coats of textured polyurethane enamel. Panel interior and exterior shall be painted white, ANSI No. 51.

D. Electrical:

1. Internal panel wiring shall be 19 strand No. 16 AWG, 90^{o}C MTW, Class C stranded, or THHN/THWN approved as 90^{o}C MTW. All panel wiring not run in wire ducts shall be bundled and tied. Each wire shall be identified at both ends with same exclusive number. Number shall be same number shown on control schematic. Number shall not be used again for any other purpose. Wires marked differently on each end will not be accepted. Wire markers shall be provided on end of each wire at termination point.
2. Control wiring associated with control circuits de-energized when main disconnect is opened shall be color-coded red. Control wiring associated with control circuits which remains "hot" when main disconnect is opened shall be color-coded yellow. DC control wiring shall be color-coded blue. Ground wires shall be color-coded

green. Terminal blocks shall be numbered in numerical order. Yellow wiring leaving panel shall be brought to an isolated set of terminal blocks.

3. Provide an instrument common bus 0.1 by 0.5 by 6-inch minimum in enclosure and isolated from enclosure. A separate instrument common wire shall be run from each common terminal on an instrument to instrument common bus. Instrument common wires looped from one terminal to another and then to instrument common bus will not be accepted.
4. Instrument common bus shall be connected to power supply common with a wire or wire braid strap as short as practical and of sufficient capacity to prevent troublesome voltage drop. Common terminals and common bus for instrument common shall be tagged "Instrument Common". Instrument signal wires of 4-20 mA or 1-5 V shall be shielded wire. Telephone wires and telemetry equipment interconnection wires shall be shielded wires.
5. Provide a copper ground bus 0.1 by 0.5 by 6-inch minimum in enclosure to which all instrument grounds and panel enclosure are tied. Separate ground wire shall be run from instrument enclosure ground terminal directly to ground bus. Instrument ground wires looped from one instrument to another will not be accepted. Under no circumstances shall neutral side of power source or any other terminals used for grounding power circuits be used as an instrument common.
6. Wires to internal components shall be connected to inside of terminal strip. Wires to external components shall be connected to outside of terminal strip. No more than 2 wires shall be connected to one terminal point.
7. Panel wire duct shall be provided between each row of components and adjacent to each terminal strip. Wire ducts shall be a minimum of 1-inch wide and 3 inches deep with removable snap-on covers and perforated walls for easy wire entrance. Wire ducts shall be constructed of nonmetallic materials with voltage insulation in excess of maximum voltage carried therein.
8. Floor-standing panels and consoles shall be equipped with a flange mounted 600V rated main non-automatic trip circuit breaker or disconnect switch. Single phase, 60 hertz power at voltage shown on Drawings shall be supplied to main disconnect. Instrumentation Supplier shall provide any additional voltages and power requirements at control panel to meet requirements of equipment contained therein.
9. In control panel enclosures with three or more doors, the disconnecting means shall be mounted at the most right-hand door.
10. The mechanical linkage between the disconnecting means and its operating handle shall ensure that the operating handle is in control of the disconnect at all times. The use of door mounted disconnect handles is prohibited. Mechanically connected panels containing less than 50 V sections do not require linkage interlock to the disconnect switch.
11. The door handle must be fully engaged to turn disconnect to "On." Mechanical interlocking shall be provided between the disconnecting means and its associated door to prevent closing of the disconnecting means:
    a. While the enclosure door is open, unless an interlock is operated.
    b. Until the door is in the fully closed position.

12. The operating handle of the disconnecting means shall only be able to be padlocked in the "OFF" position.
13. The design shall ensure that the switch cannot be closed when the operating handle is locked in the "OFF" position by a single padlock or locking device.
14. The operating handle shall clearly indicate at all times whether the disconnecting means is in the open or closed position. The operating arm shall be in the down position for "OFF" indication.
15. Disconnect and transformer shall have enclosed protected terminations to prevent accidental shock.
16. Relays, timers, etc., installed on panel subplate shall be provided with a minimum spacing between component and wire duct of 1.5 inches above and 1 inch below. Minimum spacing between adjacent components shall be 0.25 inch. Relays, timers, etc., shown in schematics are intended to show function. Additional relays may be required in conjunction with items shown to provide total number of contacts required. Where limit, pressure, float switches, etc., are used and more than SPDT contacts are indicated by schematics, provide additional contacts required by using auxiliary relays. However, if a DPDT switch is called for, using a SPDT with a relay will not be accepted. All control and pilot devices such as relays, timers, etc., shall be 120V, 3 amp rated except where noted with coil voltage as required. One normally open spare contact shall be provided on each relay.

E. Panel/Subplate Layout:

1. Panel face-mounted equipment shall consist of pilot lights, push-buttons, selector switches, meters, indicating timer, etc. Spacing between horizontal rows of components shall be 1.5 inches minimum; spacing between vertical columns of components shall be 1.875 inches minimum. Components shall be grouped and/or located as indicated on Drawings. Distance from bottom row of components to floor shall be not less than 36 inches. Top row of recording and indicating instruments shall be centered approximately 60 inches above floor. Maximum height for annunciator windows shall be 85 inches above floor. In general, indicating lights, push-buttons, etc., shall be mounted in accordance with sequence of operation from left to right and top to bottom.
2. A minimum of 2 inches shall be provided between terminal strips and wire ducts or terminal strips and terminal strips. In general, terminal strips shall be mounted on vertical edges of subplate. Where terminal strips are mounted side-by-side, terminals shall be elevated 1.5 inches above subplate to allow wires to pass underneath.
3. Subplates shall have a minimum of 15 percent spare mounting space, and terminal strips shall have a minimum of 20 percent spare terminal blocks.

F. Panels shall include lockout and tagout procedures designed to meet all OSHA and Owner requirements.

G. The requirement for air conditioners, heat exchangers, and fans shall be determined from the required heat calculations of the enclosure and the applicable ambient air temperature and humidity for the area.

H. PLC panels shall include a folding shelf, mounted to the exterior of the panel. The shelf shall support instruments and test equipment used to install and maintain electrical components in the enclosure. The shelf shall support laptop computers, monitoring units and other equipment used with programmable controllers. The shelf shall be installed on the outside surface of the enclosure, and automatically lock in the horizontal position when raised. When not in use, the shelf shall fold down and project out no more than 1 in. (25 mm) from the mounting surface.

1. Construction: Match enclosure material
2. Listing: Maintain UL/CSA Type 4, 4X and 12 rating when properly installed on enclosure.

I. Provide an externally accessible Ethernet PLC communication port on the front door of the panel to support the use of a laptop computer for programming the PLC processor without having to open the enclosure. Unit will not change the enclosure rating, and will be rated the same as the enclosure.

1. Housing: Cast aluminum base
2. Latch: Type 316Stainless Steel
3. Cover: Polycarbonate, UV rated, V-0 Flame rated
4. Gasket: Thermoplastic elastomer
5. Insert Material: Acrylic UL94HB

J. PLC's shall be Siemens Simatic and comply with Specification Section 40 94 00-Programmable Logic Controller.

2.03 SWITCH, PUSH BUTTONS, LIGHTS

A. Selector switches shall be 30.5 mm, 120 VAC rated, NEMA 4 construction with standard operator knob.

B. Start push buttons shall be 30.5 mm, 120 VAC rated, NEMA 4 construction with extended guard and black color insert.

C. Stop push-buttons shall have a half-guard with red color insert. Contacts shall be rated NEMA B-150 and P-150.

D. Pilot lights shall be LED type push-to-test with cap colors and voltages as required. Nameplates for each switch and light shall conform to manufacturer's series and type with engraving as called for on Drawings.

2.04 RELAYS

A. Control Relays: Switching and output relays shall be plug-in type with contacts rated 120 VAC, 3 amperes with 120 VAC or 24 VDC coil, indicating light, manual operator, and plastic transparent cover. Relays shall have a retainer mechanism to prevent loosening from vibration. Relays shall not be used for switching 1-5 VDC or 4-20 mA signals associated with instruments.

B. Latching Relays: Latching relays shall be transparent enclosed plug-in type with mechanical or magnetic latching, mechanical holding device, contacts rated 120V at 3 amps, and continuous duty coils. These relays shall not be used for switching 1-5 VDC or 4-20 mA signals associated with instruments.

2.05 TIMING DEVICES

A. Programmable Timer: Programmable timers shall be a multi-functional time switch suitable for flush mounting on a control panel and socket mounting. Timer shall have a adjustable dial for programming duration and mode (On-Delay, Off-Delay, One Shot, Repeat Cycle Off-Start, Repeat Cycle On-Start, and Signal On/Off-Delay).

B. Provide 5-ampere rated contacts.

C. Timers shall have a range from 0.5 seconds to 300 hours.

D. Provide multi-voltage inputs.

2.06 TERMINAL BLOCKS

A. All terminal blocks for control wiring shall have minimum continuous current capacity of 15 amperes at rated voltage 300V or 600V. The minimum size of terminal blocks shall be 2.5mm sq. and be suitable for clamping wire between 22 AWG to 10 AWG.

B. The insulation material of the housing of the terminal block shall be self-extinguishing and shall comply with UL94-V2. The contact of the terminal block shall be made of tinned pure electrolytic copper with excellent conductivity. The clamping unit inside the terminal block shall secure wire by means of cage-clamp system or positive screwing system. The minimum pull-out force exerted by the clamping unit on different size of wire shall comply with IEC-947-1. This clamping force shall remain constant over the life time of the terminal blocks and shall not diminish due to expansion and contraction of terminal or cable metal caused by the temperature cycle or load cycle.

C. Where terminal blocks are used for applications subject to vibration, cage-lamp terminal blocks shall be used. Screw-type terminal blocks shall not be accepted. These terminal

blocks shall be vibration-proof type and comply with DIN VDE 0611 (Resistance to Vibration Test for Terminal Block).

D. Where terminal blocks are used to send or receive signals to or from field devices, such as actuators, sensors, transducers, emergency stops etc., disconnect type terminal block, allowing easy trouble-shooting, shall be used. The number of operations of no-load disconnection shall not be less than 30 operations.

E. Fuse terminals, where specified and used, shall not have any loose parts, such as screw fuse cap which may fall off when replacing fuse. Fuse terminals with hinged cover shall be used.

F. Terminals shall have safe and easy means of commoning adjacent terminals. Quick fit, screw-less, touch-proof jumpers shall be used.

G. Terminal blocks used to connect cables of different voltage of shall be segregated into groups, and be preferably identified by different color. Each group of terminal blocks shall be provided with a group marker carrier. Cable having the same ferrule number shall be terminated at adjacent terminal, and connected by means of cable jumper at the terminal blocks. At least 30% spare terminal blocks shall be provided for each type of the terminal block.

H. Terminal blocks shall be color-coded according to the following coloring scheme:

Black	120 VAC power circuits de-energized when main disconnect is opened.
White	120 VAC neutral conductors.
Red	120 VAC control circuits de-energized when main disconnect is opened.
Yellow	120 VAC control circuits which remain hot when main disconnect is opened.
Blue	Terminal blocks for DC wiring.
Gray	Terminal blocks for shields in DC wiring.
Green	Ground terminal blocks.

I. For terminals associated with 120 V nonisolated input cards, individually fused terminal blocks shall be used for 120 V power to field devices.

J. Terminal blocks shall be raised so that the top of the block is flush with the top of the adjacent wire duct.

2.07 CONTROL POWER TRANSFORMERS

A. Control power transformers shall be sized to handle in-rush currents and to accommodate continuous load of circuits plus 25 percent future load with 5 percent or less voltage drop. Transformer primary voltage shall be as indicated on Drawings.

PART 3 EXECUTION

3.01 GENERAL

A. Examination to include the minimum:

1. Vacuum interior of cubicles and remove foreign material.
2. Wipe clean with a lint-free cloth insulators, bushings, bus supports, etc.
3. Check and adjust time delay, under-voltage devices, phase relay, over-current relays, etc., as required by coordination study or Engineer.
4. Equipment with two (2) or more sources of power connected by tie breakers, transfer switches, or generator receptacles shall be checked for rotation from each possible combination of power sources. Power sources must have the same phase sequence for each source throughout entire facility.
5. Check exposed bolted power connections for tightness.
6. Check operation of breakers, contactors, etc., and control and safety interlocks.
7. Check tightness of bolted structural connections.
8. Check leveling and alignment of enclosures.
9. Check operating parts and linkages for lubrication, freedom from binding, vibration, etc.
10. Check tightness and correctness of control connections at terminal blocks, relays, meters, switches, etc.
11. Clean auxiliary contacts and exposed relay contacts after vacuuming.

B. Refer to appropriate Division 40 specifications for installation and testing requirements.

END OF SECTION

SECTION 40 95 14
SPARE PARTS

PART 1 GENERAL

1.01 SUMMARY

A. Where not otherwise covered in specific Sections, spare parts shall be provided in accordance with this section. This Section applies to:

1. Instrumentation system spare parts.

2. PLC and remote I/O

3. Control Panels

1.02 SUBMITTALS

A. Shop Drawings: Submit shop drawings in accordance with Sections 01 33 00 and Section 40 91 00 covering the items included under this Section. Shop Drawing submittals shall include:

1. Spare Parts List: Submit a list of recommended spare parts for the equipment provided.

1.03 DELIVERY

A. Deliver spare parts to Owner prior to final acceptance of instrumentation system and equipment.

PART 2 PRODUCTS

2.01 SPARE PARTS

A. After completion and final owner acceptance of the system operation, provide spare parts as recommended by the equipment manufacturer necessary to support maintenance of the systems for a period of one (1) year under normal operating conditions.

B. Spares parts shall not be used to replace faulty or damaged parts during construction and starup.

C. Provide the following:

1. One (1) spare relay of each type used.

2. One (1) year supply of expendable spares such as lamps, fuses, etc.

3. One (1) spare sensor of each type used on the project.

D. Provide the following: (includes equipment specified under other sections)

1. On systems employing PLCs, provide one ()1 spare circuit card of each type used in delivered equipment. Circuit cards shall include the following (matching units in service):

   a. Analog input card.

   b. Analog output card.

   c. Discrete input card.

   d. Discrete output card.

2. One (1) spare Ethernet card and cable.

3. Provide one (1) spare processor of each type used on the project.

4. Provide one (1) spare module of each type listed below:

   a. Communication card.

5. Provide a box of fuses for each size and type used.

6. One (1) spare power supply module for each type used on the project.

E. Provide a full-size computer grade steel cabinet to house all spare parts and test equipment supplied.

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 40 95 80
FIBER OPTIC COMMUNICATION SYSTEM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. Institute of Electrical Electronic Engineers, Inc. (IEEE); 802.3 Telecommunication and Information Exchange Between Systems.
2. International Organization for Standardization (ISO).
3. National Electrical Code (NEC).
4. Telecommunications Industry Association (TIA); Electronics Industry Association (EIA)
   a. 492, Specifications for Optical Waveguide Fibers.
   b. 568, Commercial Building Telecommunications Cabling Standard.
   c. 569, Commercial Building Standards for Telecommunications Pathways and Spaces.
   d. 607, Commercial Building Grounding and Bonding Requirements for Telecommunications.

1.02 ABBREVIATIONS

A.	AUI	attachment unit interface.
B.	dB	decibel.
C.	DNI	desktop network interface.
D.	FDDI	fiber distributed data interface.
E.	FOCS	Fiber Optic Communication Subsystem.
F.	FOIRL	Fiber Optic Inter Repeater Link.
G.	LAN	local area network.
H.	MHz	megahertz.
I.	micro	x 10^{-5}
J.	Mbps	megabits per second.
K.	N	newton.
L.	n, nano	x 10^{-9}
M.	nm	nonometer
N.	OTDR	optical time-domain reflectometer.
O.	PICS	Process Instrumentation and Control System.
P.	µm	micrometer
Q.	UPS	uninterruptible power supply
R.	V ac	volts alternating current
S.	WAN	wide area network.

1.03 SYSTEM DESCRIPTION

A. This section covers requirements for Fiber Optic Communication Subsystem (FOCS) and is in addition to 40 91 00 Process Control and Instrumentation.

B. The function of FOCS is to transmit digital data between network nodes. Requirements listed identify the minimum acceptable system performance.

C. Provide a FOCS based on referenced standards for use in the following local and wide area networks:

1. Ethernet.
2. Fast Ethernet.

D. Network(s) will be used by PICS to distribute data and coordinate Owner's operations.

1.04 SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 00.

B. Action Submittals:

1. Site layout diagram showing:
   a. Access holes, with identification.
   b. Abovegrade cable routings, with pole and cable identification.
   c. Belowgrade conduit routings between access holes and buildings, with conduit counts and identification.
   e. Cable routings through ducts and to patch panels, fiber centers, or network nodes, with cable and node identification.
2. Cable schedule showing:
   a. Cable identification.
   b. Fiber counts for each cable and identification of used fiber pairs.
   c. Cable length and attenuation, with 2 connector pairs and no splices, based on TIA/EIA 568, Annex H.
3. Component Data:
   a. Manufacturer and model number.
   b. General data and description.
   c. Engineering specifications and data sheet.
   d. Scaled drawings and mounting arrangements.

B. Informational Submittals:

1. Manufacturer's statement that installer is certified to perform installation Work.

2. Subcontractor Qualifications:
    a. FOCS Subcontractor: Minimum of 5 years experience providing, integrating, installing, and commissioning of similar systems.
    b. FOCS Subcontractor's Site Representative: Minimum of 5 years experience installing similar systems.
    c. Owner acceptance of FOCS Subcontractor does not exempt FOCS subcontractor or Contractor from meeting Contract Document requirements nor does it give prior acceptance of subsystems, equipment, materials, or services.
        1) Statement of Experience: List of at least 3 fiber optic data communications systems comparable to the system specified which have been furnished and placed into operation by prospective FOCS Subcontractor. For each system, provide following information:
            a) Owner's name, address, telephone number, and name of current operations supervisor or other contact.
            b) Description of system hardware configuration, including major equipment items, number of nodes, and communication standards implemented.
            c) System block diagram.
        2) Qualification of Personnel:
            a) Resumes giving management and technical qualifications of supervisory, local service representative, and key personnel.
            b) For each maintenance organization, identify location of base of service and how required coverage will be achieved.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
4. Manufacturer's suggested installation practice.
5. Testing related submittals.
    a. OTDR certification, current within last 12 months.
    b. Test Documentation. As specified under paragraph Pre-Installation Testing.
    c. Post-Installation Test Documentation.
        1) As specified under paragraph Post-Installation Testing.
        2) An updated version of the link calculations specified under paragraph Shop Drawings including:
            a) Actual cable lengths used.
            b) Actual losses measured by the tests.
            c) Revised light margin calculations.
6. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
    a. Updated versions of all Shop Drawings.
    b. Post-Installation Test Documentation.

c. Component Manuals: Include manuals to cover installation, operation, maintenance, troubleshooting, and calibration.
d. List of spare parts and expendable provided and list of recommended spare parts.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Optical Fiber Cable and Cable Splice Centers:

1. Outside, Underground/Submerged: Minus 20 to 40 degrees C.
2. Outside, Overhead: Minus 40 to 80 degrees C.
3. Outside, Aboveground in Conduit: Minus 40 to 80 degrees C.
4. Inside: 0 to 40 degrees C.

B. Equipment:

1. Outside, Aboveground: Minus 40 to 80 degrees C.
2. Control Rooms, Equipment Rooms and Telecommunications Closets: 30 to 55 percent relative humidity, 18 to 24 degrees C.
3. Other Interior Areas: 0 to 100 percent relative humidity, 5 to 35 degrees C.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and materials:

Item	Quantity
Jumpers of each length needed	100 %
Fiber Optic Cable Maintenance Tools	One complete set

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 MATERIALS

A. Fiber Optic Cable:

1. Fiber Characteristics: Single-Mode.
   a. Comply with TIA/EIA 568.
   b. 8.31125 µm glass single-mode.
   c. Tight-buffered, 900 µm buffer:
      1) Inner buffer: Acrylate, UV-cured, soft.
      2) Outer buffer: PVC, elastomeric, hard.

d. Maximum Attenuation: 130011550 nm: 0.5 dB/km.
e. Color-coded buffer.
f. Minimum Bend Radius, Buffered Fiber: 1inch.
g. Proof Testing: 100 kpsi.

2. Fiber Characteristics: Multimode
   a. Comply with TIA/EIA 568.
   b. 501125 µm graded-index glass.
   c. Tight-Buffered, 900 µm buffer:
      1) Inner buffer: Acrylate, UV-cured, soft.
      2) Outer buffer: PVC, elastomeric, hard.
   d. Maximum Attenuation:
      1) 850 nm: 3.0 dB/km.
      2) 1300 nm: 1.0 dB/km.
   e. Minimum Bandwidth:
      1) 850 nm: 1500 MHz-km.
      2) 1300 nm: 500 MHz-km.
   f. Color-coded buffer.
   g. Minimum Bend Radius, Buffered Fiber: 1 inch.
   h. Proof Testing: 100 kpsi.

3. Cable:
   a. Fiber Count:
      1) Single-mode: 12 fibers per cable, minimum.
      2) Multimode: 12 fibers per cable, minimum.
      3) Multimode Breakout: 2 fibers per cable, minimum.
   b. All Dielectric Construction: No electrically conductive components in fiber optic cable are allowed.
   c. Helically Wound: Buffered fibers helically wound; approximately turns per meter.
   d. Gel-Free: Fibers tight-buffered, not in gel-filled loose-tube.
   e. Core-Locked with no separator tape.
   f. Style [Except Multimode Breakout]: Distribution.
   g. Style [Multimode Breakout]: Breakout. Suitable for direct fiber termination using standard connectors.
   h. Strength Member:
      1) Nonconductive; integral part of cable; supports stress of installation and load during use.
      2) Fiberglass epoxy rod, fiber, kevlar.
      3) Minimum Tensile Strength: 1301400 pounds long-term and short-term respectively.
   i. Protective Covering:
      1) High-temperature Plenmu Fluoropolymer.
      2) Continuous and free from holes, splices, blisters, and other imperfections.
   j. Minimum Bend Radius:
      1) Short-term Under Tension: 20 times cable diameter.
      2) Long-term Without Tension: 15 times cable diameter.

k. Identification:
   1) Identify with tags shown and in accordance with Section 40 91 00 Instrumentation and Control Components.
   2) Use waterproof tags and identifications.
l. Special Features: Plenum rated flame-retardant.
m. Manufacturer: Optical Cable Corporation.

B. Ethernet Fiber-To-Copper Transceivers:

1. Function: Convert fiber optic Ethernet signal (10Base-FL) to copper signal.
2. Features:
   a. Support fiber optic type specified
   b. Fiber Optic Connectors: ST
   c. Copper Connector: RJ45 shielded.
   d. Power:
      1) Powered by signal, or
      2) 120 Vac
   e. Mounting: Suitable for permanent mounting.
3. Manufacturers and Products:
   a. MOXA
   b. Omnitron
   c. Black Box
   d. Tripplite

C. Fiber Optic Patch Panel, Rack Mount:

1. Function: Provides industry-standard rack mounting system for interface between fiber optic backbone and equipment cables.
2. Features:
   a. Used in either cross-connect or interconnect configuration.
   b. 23-inch rack for mounting 19-inch rack mount units.
      1) Accommodates up to 576 fiber terminations per frame.
      2) Accepts connector module housing and splice housing within same rack.
      3) Fiber Optic Connectors: SC and ST.
   c. Fiber/Wire Management System:
      1) Vertical: 3-inch by 4-inch supports on 8-inch centers vertically on four sides (front LHS, back LHS, front RHS, back RHS).
      2) Horizontal: Supports on 4-inch centers horizontally above and below each termination frame front and back. Support may serve frames immediately above and below.
   d. Mounting Hardware: Accepts standard 19-inch rack for integrated fiber optic system hubs, routers, patch panels, etc.).

e. Splice Trays with Coil Former: Former to wind slack cable around, provides controlled long radius bends.
   1) Doors: Pivot down lockable.
   2) Foot and End Caps: Included in final, assembled unit.
   3) Jumper troughs and covers, cable tie brackets.

3. Manufacturers:
   a. Ortronics.
   b. Corning.

D. Fiber Centers:

1. Function: Provides a secure place to terminate fiber optic cables.
2. Features:
   a. Compartments: Two; one for fiber optic cable, one for jumpers to individual equipment.
   b. Coil Former: Former to wind slack cable. Provides controlled long-radius bends.
   c. Connectors: Minimum 24 ST connectors for entry and exit.
   d. Size: Maximum 18 inches by 12 inches by 4 inches.
   e. Construction: 1.5-millimeter steel with noncorrosive finish.
   f. Mountings: Suitable for permanent attachment as shown, or provide separate mountings that do not obscure covers and doors.
   g. Doors: Separate doors for cable and jumper and lockable.
3. Manufacturers and Products:
   a. Ortronics; OR-615SMFC.
   b. Corning.

E. Splice Housings:

1. Function: House splices and serve as pulling box.
2. Features:
   a. Size: In accordance with TIA/EIA 569, Table 4.4-2
   b. Mounting: Suitable for standard 19-inch rack or wall mounting
   c. Environment: Outside, aboveground
   d. Enclosure: NEMA 4
3. Manufacturers and Products:
   a. Corning; FSC
   b. Approve equal

F. Splice Closures, Aerial and Underground:

1. Function: Enclose branch and inline splices in aerial and underground applications.
2. Features:
   a. Environment: Outside overhead, outside underground.
   b. Material: Hard black plastic and aluminum

c. Cables Per Closure, Inline: One in, one out maximum
d. Cables Per Closure, Branch: As required for design, but no more than limitation of closure
e. Bonding and grounding kit
f. Splice holders for fusion or mechanical splices

3. Manufacturers and Products:
a. For 24 splices or fewer: AT&T; Fiber Optic Splice/Drop Closure 2500LG
b. For more than 24 splices: AT&T Fiber Optic Closure UCB1 with 51D3-LG2 housing

G. Connectors

1. Features:
a. In accordance with requirements of TIA/EIA 568, Section 12.4.3 or Annex F.
b. SC and ST connectors with 12.7 millimeter spacing between ferrules.
c. Pull Strength: 0.2 N minimum.
d. Durability: Sustain minimum 500 mating cycles without violating other requirements.
1) Ferrules: Free-floating low loss ceramic.
2) Polarizing key on duplex connector systems.

2. Quantity: Connectorize fibers, minimum per cable:
a. Single-mode: All fibers.
b. Multimode: All fibers.

3. Attenuation:
a. In accordance with requirements of TIA/EIA 568, Section 12.4.4.
b. Maximum of 0.75 dB per connector pair.

4. Manufacturer:
a. Corning Unicam
b. Amp
c. Approved Equal

H. Jumper Cables:

1. In accordance with requirements of TIA/EIA 568, Section 12.5.
2. Function: To connect from fiber centers to network nodes, such as computer workstations.
3. Fiber Characteristics: In accordance with requirements for fiber optic cable.
4. Cable Configuration:
a. Individual tight-buffer thermoplastic, fibers single or multimode, to match fibers being jumpered on.
b. Protected with kevlar strength members and enclosed in thermoplastic jacket.

5. Length: Standard, to meet requirements shown, plus minimum 3 meters at workstations.
6. Connectors:
   a. As required by Article Connectors.
   b. On-axial Pull Strength: 33 N.
   c. Normal-to-Axial Pull Strength: 22 N.
7. Communications Management Outlets:
   a. In accordance with TIA/EIA 568, Section 12.4.5.
   b. Function: Provide organized system for connecting workstations into precabled communications.
   c. Cover Plates:
      1) Flush and extension mount, as required to provide bend radius and space for coiled cable.
      2) Materials: ABS plastic.
      3) Color: White, unless otherwise indicated.
      4) Identifiers: Color-coded identification strips.
   d. Connectors:
      1) ST connectors, counts as shown.
         a) Multimode: ST.
      2) Sleeves: Phosphor bronze.
      3) Mounting: Face.
   e. Manufacturers and Products:
      1) Ortronics; Series II.
      2) AMP; Fixed Shroud Duplex (FSD) System.

PART 3 EXECUTION

3.01 PREPARATION

A. Conduits are provided under Division 26, Electrical.

1. Ensure that the installed conduit system is acceptable for fiber optic system requirements, including:
   a. Conduits: Size and number.
   b. Access Holes, Handholes, and Pull Boxes: Location and size, to ensure cables can be installed without exceeding manufacturer's pulling limitations.
   c. Outlet Boxes: Size to coordinate with outlet cover plates for adequate volume and bend radius.
2. Spare Conduits:
   a. No cables shall be pulled into spare conduits.
   b. 100 percent spare conduit capacity required for all buried conduits only, i.e., for every conduit with one or more cables in it, there shall be one spare equal-size conduit with no cables.

3. Expansion Plugs: Seal conduits to stop ingress of water and grit with fabricated expansion plugs.

B. Fiber Optic Cable:

1. Installation by manufacturer certified installer.
2. Install cables in accordance with manufacturer's requirements.
3. Install cable directly from shipping reels. Ensure that cable is not:
   a. Dented, nicked, or kinked.
   b. Subjected to pull stress greater, or bend radius less, than manufacturer's specification.
   c. Subjected to treatment that may damage fiber strands during installation.
4. If calculation indicate that the cable will attenuate signals more than 8 dB, reroute as necessary and document in final as-built configuration submittals.
5. Splices: Install fiber optic cables in unspliced lengths from fiber centers to switches or hubs.
6. Identification: Identify cable on both ends, in access holes and at pull points it goes through.
7. Sealing: Seal cables into ducts to stop ingress of water and grit with fabricated expansion plugs.
8. Access Holes:
   a. Provide supports for cables in access and handholes at minimum of 24 inches on-center along sides.
   b. While maintaining minimum bend radius, lace cables neatly to supports to keep them out of way of personnel.

C. Fiber Centers:

1. Install securely in field panels or equipment racks as shown.
2. Minimum, one per facility having one or more network nodes.

E. Cable Terminations:

1. Terminate cables in accordance with TIA/EIA 568.
2. Fan out fiber cable to allow direct connectorization of connectors. Sleeve over individual fibers with transparent furcation tubes. At point of convergence of furcation tubes, provide strain relief with metal or high density plastic fan-out collar.
3. Break-Out Kits:
   a. Terminate cables using manufacturer-supplied break-out kits.
   b. Terminate in accordance with recommendations.
4. Slack:
   a. Fiber Centers, I-Iubs, and Switches: Minimum, 3-meter slack fiber at each end, coiled neatly in cable management equipment.

b. Communications Management Outlets: Minimum, 10 feet of slack fiber, coiled neatly in outlet box.

5. Connectors:
   a. Terminate 100 percent fibers in each cable to specified connectors.
   b. Connect into fiber management system.

F. Ethernet Fiber-to-Copper Transceivers:

1. Install transceivers in accordance with manufacturer's instructions.
2. Location: Install transceivers securely in field panels, close to network nodes and fiber centers.
3. Power: Energize each transceiver from its field panel's UPS, if applicable.
4. Connections:
   a. Connect transceiver to fiber optics and network node.
   b. Lace fiber optics neatly in place, routed through wireways.

3.02 FIELD QUALITY CONTROL

A. Test components of installation in accordance with standards and specifications.

B. Provide equipment, instrumentation, supplies and skilled staff necessary to perform testing.

C. Advise Engineer at least 48 hours in advance of each test. Engineer or owner shall have the option to witness and participate actively in tests.

D. Document test results of each cable to confirm that at least specified number of fibers meet standards, in accordance with Supplement titled As-Built Fiber Optic Cable Installation.

E. For each conduit, complete As-Built Conduit Installation form included as Supplement to this section.

F. Document results of transceiver tests.

3.03 TESTS AND INSPECTION

A. In accordance with Section 01 91 14, Equipment Testing and Facility Startup.

B. Conduit:

1. Test and Seal Spare Conduits.
2. Conduit Testing:
   a. Blow full-diameter mouse through each spare conduit to verify they are unrestricted over full length.
   b. If any conduit is not unrestricted over full length, advise Engineer.

C. Cable Testing:

1. Test Cables Twice:
   a. On the reel, just prior to installation.
   b. Post-installation.
   c. Compare results.
   d. Submit results.
2. TIA/EIA 568: Demonstrate that 100 percent fibers in each cable meet requirements of TIA/EIA 568, Annex H, as modified here:
   a. Maximum attenuation as specified in Part II, Fiber Optic Cable.
   b. Measure attenuation in both directions, not in one direction only.
   c. For multimode fibers only: Measure attenuation at both 850 nm and 1,300 nm.
3. Replace and retest cables that do not have specified number of fibers that meet attenuation standards.

D. Ethernet Repeaters:

1. Do not provide repeaters until tests have demonstrated that unrepeated fiber optic communications are not successful.
2. If Tests Are Not Successful:
   a. Install repeaters in accordance with manufacturer's instructions.
   b. Location: Install repeaters securely on 19-inch racks in field panels.
   c. Power: Energize repeaters from field panel's UPS.
   d. Connections:
      1) Connect repeaters to fiber optics via fiber centers.
      2) Lace fiber optics neatly in place. Do not route fiber optics through in field panels.
   e. Demonstration Test:
      1) Demonstrate correct operation of each repeater using network communications.
      2) Document results of each test.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: The manufacturer's representative shall be present on-site for the minimum person-days listed below, travel time excluded:

1. 1 person-day for installation assistance and inspection.
2. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1/2 person-day for pre-startup classroom or Site training.

4. 1/2 person-day for post-startup training of Owner's personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Engineer.

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

3.05 TRAINING

A. Train Owner's staff in the following

1. Make-up of fiber terminations.
2. Splicing optical fiber cables, including fiber splices.
3. Testing quality of connectors, splices and fibers.

B. Schedule: Provide one 8-hour training session.

C. Materials: Provide hardware for training, including fibers, connectors, and splice kits.

D. Tools: Provide two (2) sets of tools for trainees' to use. Ensure that the tools are available prior to the start of training.

END OF SECTION

SECTION 40 96 35
PROCESS CONTROL SOFTWARE PROGRAMMING

PART 1 - GENERAL

1.1 SUMMARY

A. Work includes programming, testing, and installation of software required for a complete and fully operational control system. Principal segments of Work include, but are not limited to, programmable logic controller ladder logic, data collection, supervisory control, operator process control interfaces, process data management, and plant administrative/management reports.

1.2 SYSTEM DESCRIPTION

A. This Section provides functional descriptions of the PLC and computer software requirements for the instrumentation and control system as indicated on the Drawings and specified herein. These descriptions are intended to provide an overview of the operating concept of the plant process equipment rather than describing in detail every operating feature or interlock.

B. See Attachments 40 96 35 A through 40 96 35 U for system process control and HMI functionality requirements and an I/O list.

1.3 ACTION SUBMITTALS

A. Format: Text and picture documents shall be provided in color to insure the accuracy of each item. No black and white copies will be accepted. The colors used in the printed submittal shall accurately depict the colors and shapes proposed for use on the final system. In addition to paper copies, Contractor shall supply editable electronic files in their native format.

B. Shop Drawings: Submit in accordance with Section 01 33 00, Shop Drawings and product data for products provided under this Section.

1. Detailed functional descriptions of all software modules specified and furnished as part of Instrumentation Supplier's system. The descriptions shall be identified with the applicable specification paragraph from this Section. The document shall be submitted for review and approval before software configuration commences. The document should provide text based narrative describing each piece of equipment's control scheme. The document should include HMI graphic screens diagrams and control overlays (pop-ups) and animation plan. The text shall cover applicable local, remote, automatic, and manual modes of control. Permissive, interlocks, discrete alarms, analog alarms, totalized values, equipment run

timers, and historical trended values shall be stated for each process area. Instructions shall be short, easy-to-understand directions specifically written for this project describing various components functionality.

2. Software Programs: One (1) fully annotated printed copy of programming prior to factory test. In addition, provide required number of copies of latest revisions of program at time of acceptance by Owner. Submittal of printouts, listings, and screen images shall be supplied on paper (hard copy). With concurrence of Owner and Engineer, machine readable magnetic copies may be supplied in addition to printed copies as a matter of convenience. Format of magnetic media shall be as mutually agreed with Owner.

3. Programmable Logic Controllers: Submits lists of input and output assignments, data file structures used, and internal data points. Show points used to communicate between PLCs and the operator interface and data collection segments. Include complete, fully annotated ladder logic diagrams complete with cross-reference listings.

4. Operator Interface and Supervisory Control: Submit "screen dump" images of each proposed operator interface screen (HMI screen) and images of historical trending. Describe color schema, mouse button use, function key controls and communication protocol with PLCs. Provide a flow diagram showing screen navigation. Show sample event and alarm log outputs.

5. Data Management and Reporting: Describe data collection, and reporting scenarios. Describe data file storage management including backup and archive operations.

6. Security; Document every user name and password required for any new or modified control equipment.

C. Software Configuration Standards and Conventions

1. A software configuration standards and conventions document shall be prepared by the Instrumentation Supplier and submitted by the Contractor. The document shall be submitted for review and approval before software configuration commences. Before submitting the initial draft document, the Instrumentation Supplier shall meet with the Engineer and Owner to review any of the Owner's existing standards and conventions.

   a. Operator Interface Software: This section shall describe and define such items as proposed graphic display process line colors/representations; color standards for "on", "off", "opened",

"closed", and "alarm" conditions; alarm handling conventions; how items will be selected for control; methods for navigation between displays; address usage/naming conventions; file storage and space management; trending; and security setup.

b. Logic Controller Programming: This section shall describe and define such items as proposed ladder logic format; tag and alias structure/naming standards; interlocks for manual and automatic logic; series, parallel, seal-in, debug bits, latch and un-latch standards; pump, valve, and motor standard logic; alarming, data buffering, signal scaling (including dead band, minimum and maximum limits), maintenance modes, out-of-service modes, flow totalizers, and run time counters; messaging, error checking, time syncing, and fault handling.

2. The software configuration standards and conventions document shall include the Wonderware database interface system.

D. In addition to submitting the documents above for review, an updated version of the documents shall be submitted as part of the operation and maintenance manuals. The document shall be revised to document any additional changes to control schemes that are established throughout the project process.

E. Factory Test Procedure (FAT): Provide documentation containing factory test methods and procedures.

F. Site Acceptance Test (SAT): The SAT procedure shall refer to the actions and expected results to demonstrate that the control system performs in accordance with the specified sequence of control. Include a list of the equipment to be used during the testing plus manufacturer's name, model number, equipment function, the date of the latest calibration and the results of the latest calibration.

G. Operator Training Manuals:

1. Training manuals shall be submitted twenty-one (21) days before the Preliminary Operator Training is scheduled. After approval a copy of the training manual for each trainee plus two (2) additional copies shall be delivered to the Engineer. Manuals shall include an agenda, the defined objectives for each lesson, and a detailed description of the subject matter for each lesson. Furnish audiovisual equipment and other training supplies and materials. Copies of the audiovisuals shall be delivered with the printed training manuals. The Owner reserves the right to videotape training sessions for later use.

2. The Contractor shall submit a training schedule for approval. Approval of the Contractor's training schedule shall be obtained from the Engineer at least 10 days before the training.

1.4 INFORMATIONAL SUBMITTALS

A. Submit the following:

1. Factory Acceptance Test (FAT)

2. Site Acceptance Test (SAT)

3. Network Condition Assessment

1.5 CLOSEOUT SUBMITTALS

A. Submit the following:

1. Warranties and bonds in accordance with Section 01 74 00.

2. Operation and maintenance data in accordance with Section 01 78 23.

.

3. Project record documents in accordance with Section 01 78 39.

1.6 QUALITY ASSURANCE

A. Programming shall be provided by the Instrumentation Supplier as defined in Section 40 91 00.

B. Codes and Standards:

1. National Electric Code.

2. Applicable State and local requirements.

3. American National Electrical Manufacturers Association.

4. American Water Works Association.

5. International Electrotechnical Commission

6. International Society of Automation.

7. Open Modular Architecture Controls (OMAC) Users Group.

C. Proposed graphic screen report formats and security shall be reviewed with the Owner and Engineer throughout the configuration process. The Instrumentation Supplier's programming personnel shall attend an initial review meeting as well as a second review meeting, held at approximately 50 percent completion, but prior to the FAT.

D. Calibration Equipment and Testing Apparatus: Equipment supplier shall have available test and calibration equipment for factory panel tests, installation, start-up, and troubleshooting purposes.

PART 2 - PRODUCTS

2.1 SOFTWARE SERVICES

A. Software services shall be provided by the Instrumentation Supplier as described in Section 40 91 00 and herein. All PLC and HMI programming shall be provided by the Instrumentation Supplier as defined in Section 40 91 00.

B. Software services include program development, testing, documentation, and work necessary to implement a complete and fully operating system as shown on Drawings and as specified. Provide programming to implement required functions and features.

C. Work requires coordination with concurrent program development for PLCs, HMIs, management reports, and data collection. Include PLC error detection logic for communications failures, faults, internal faults, and time outs. Communicate PLC error conditions to HMIs for logging and reporting.

D. General functional requirements for system configuration are indicated on the Drawings and described in the Specifications. The information presented herein and indicated on the Drawings illustrates the general functional intent of the system, and may not be sufficient to fully configure the system. The Instrumentation Supplier shall be responsible for determining what additional information may be required to complete the configuration tasks, and for obtaining this information from the Engineer or the Owner. No additional compensation will be provided for such work.

E. Control System Database. The control system database shall be developed and configured by the Instrumentation Supplier who shall enter information obtainable from the Contract Documents into the database prior to soliciting input from the Engineer and the Owner. The Instrumentation Supplier shall determine the need for any "pseudo" database points and shall ascertain and enter all information needed to define these points. The Instrumentation Supplier is responsible for entering all information associated with each point. This includes, but is not limited to, descriptions, engineering units, associated displays, areas,

security, etc. All fields associated with each database point must be completely filled out accurately. Database shall follow ISA standards including ANSI/ISA-506.01-2007.

F. Graphic Screen Displays. The Instrumentation Supplier shall be responsible for developing and configuring the custom graphic displays. Each piece of major process equipment that is monitored by the control system shall be displayed on one or more graphic screens. Graphic screens shall be representations of the equipment and piping. The screens must accurately show all devices and equipment that is part of the control loops. These items must be done in accordance to the configuration standards and conventions as described earlier in this Section. The requirement for alarm and/or event displays shall also be provided and proven functional prior to acceptance of the system. A means of capturing and printing of all graphic screens shall also be included. The software program provided must be capable of printing the screen in a black and white (using gray scale) or color format. This program must be accessible from all terminals provided under this Contract. The black and white printing shall be done in a manner in which the use of the black background is not represented in the printout. This is done to keep the utilization of ink cartridge and toner cartridge to a minimum.

G. Report Formats. Report formats shall be developed and programmed by the Instrumentation Supplier using tag names defined in the database creation. Reports shall be produced within 30 seconds from operator request.

H. Alarming shall utilize the EEMUA 191, ISA-18.1, and RP77.60.02-2000 standards for structure, implementation, and occurrence. The time required for the operator interface panel (Factor Talk) to display an alarm shall not exceed 20 seconds.

I. Communication between PLCs, HMIs, and data collection components shall be on an exception basis. When reportable changes in process state occur, such as alarm assertion, return to normal or analog value out of dead band and report event to PLC that communicates with HMI and data collection system. The PLC shall maintain data tables current with all process inputs and outputs. Organize data to be transferred into contiguous blocks of information using bit-mapped and integer tables. Employ a "watchdog" timer for each remote PLC and poll that PLC if no message has been received in a reasonable amount of time notify an operator with an alarm. Accept HMI directives for setpoint changes and hand switches.

J. Database shall be designed to limit data growth rate. Database shall not exceed 1 GB a year. Instrumentation Supplier shall monitor database for 3 months after all points are configured. Database shall have a 98% availability (98% of the system data will be stored to the database).

2.2 PROGRAMMABLE CONTROLLER LOGIC

A. Develop programs for execution on PLCs using development software supplied under that Section 40 94 00. Logic shall perform functions required to control processes and equipment as shown on Drawings and as specified. Develop complete cross-references for ladder logic and complete input/output listings.

B. Operating System: Each PLC shall maintain a point database in memory that includes all parameters, constraints and the latest value or status of all points connected to the PLC. Execution of the PLC application programs shall use the data in memory resident files. All code shall be defined as a mix of function blocks, ladder logic diagrams, sequential function charts and text programming. Programming methods and interactions shall be based on IEC 61131-3. Combinations of the programming methods are allowed within a single controller. The operating system shall allow loading of software locally or from the central station. It shall also support data entry and diagnostics using an operator interface panel attached directly to the PLC.

1. Startup: The PLC shall have startup software that causes automatic commencement of operation without human intervention, including startup of all connected I/O functions. A PLC restart program based on detection of power failure at the PLC shall be included in the PLC software. The restart program shall include start time delays between successive commands to prevent demand surges or overload trips.

2. Failure Mode: Upon failure for any reason, the PLC shall perform an orderly shutdown and force all PLC outputs to a predetermined (failure mode) state, consistent with the failure modes shown and the associated control device.

C. Functions:

1. Analog Monitoring: The system shall measure and transmit all analog values including calculated analog points.

2. Logic (Virtual): Logic (virtual) points shall be software points entered in the point database which are not directly associated with a physical I/O function. Logic (virtual) points shall be analog or digital points created by calculation from any combination of digital and analog points, or other data having all the properties of real points, including alarms, without the associated hardware. Logic (virtual) points shall be defined or calculated and entered into the database. The calculated analog point shall have point identification in the same format as any other analog point.

3. State Variables: If an analog point represents more than two (up to 8) specific states, each state shall be nameable. For example, a level sensor

shall be displayed at its measured engineering units plus a state variable with named states usable in programs or for display, such as low alarm/low/normal/high/high alarm.

4. Analog Totalization: Any analog point shall be operator assignable to the totalization program. Up to eight analog values shall be totalized within a selectable time period.

5. Trending: Any analog or calculated point shall be operator assignable to the trend program. Up to eight points shall be sampled at individually assigned intervals, selectable between 1 minute and 2 hours. A minimum of the most recent 128 samples of each trended point shall be stored. The sample intervals shall be able to be defined, modified, or deleted online.

D. Alarm Processing:

1. Digital Alarms: Digital alarms are those abnormal conditions indicated by digital inputs as specified and shown. The system shall automatically suppress analog alarm reporting associated with a digital point when that point is turned off.

2. Analog Alarms:

a. Analog alarms are those conditions higher or lower than a defined value, as measured by certain types of field instruments. Analog readings shall be compared to predefined high and low limits, and alarmed each time a value enters or returns from a limit condition. Unique high and low limits shall be assigned to each analog point in the system. In control point adjustment (CPA) applications, key the limit to a finite deviation traveling with the setpoint. The system shall automatically suppress analog alarm reporting associated with an analog point when that analog point is turned off.

b. Each analog point will have a low alarm, low warning, normal, high warning, and high alarm. All alarms may be turned off or on from the HMI.

E. Constraints: Each control point in the database shall have PLC resident constraints defined and entered by the Instrumentation Supplier, including as applicable: maximum starts (cycles) per hour; minimum off time; minimum on time; high limit (value in engineering units); and low limit (value in engineering units).

F. Constraints Checks: All control devices connected to the system shall have the PLC constraints checked and passed before each command is issued. Each

command point shall have unique constraints assigned. High and low "reasonableness" values or one differential "rate-of-change" value shall be assigned to each analog input. Each individual point shall be capable of being selectively disabled by the operator from the HMI.

G. Control Sequences and Control Loops:

1. Specific functions to be implemented are defined in individual system control descriptions and shall include, as applicable, the following functions: PI control shall provide proportional control and proportional plus integral control; two position control shall provide control for a two state device by comparing a set point against a process variable and an established dead band; floating point control shall exercise control when an error signal exceeds a selected dead band, and shall maintain control until the error is within the dead band limits; signal selection shall allow the selection of the highest or lowest analog value from a group of analog values as the basis of control and shall include the ability to cascade analog values so that large numbers of inputs can be reduced to one or two outputs; signal averaging shall allow the mathematical calculation of the average analog value from a group of analog values as the basis of control and shall include the ability to "weight" the individual analog values so that the function output can be biased as necessary to achieve proper control; reset function shall develop an analog output based on up to two analog inputs and one operator specified reset schedule.

2. PIDE Basic Loop Control:

a. Standard software algorithms shall be available to perform regulatory control functions, and these shall have easily configurable parameters.

b. Basic loop control should be supported by the system via open loop tuning. Enhanced proportional, integral, derivative (PIDE) control loops shall be supported through the function block diagram and structured text control functions. These control functions can be used to create continuous and batch process PIDE control loops. Online editing shall permit changes to control loop strategies while they are operating.

c. It shall be possible to put any individual control loop in a manual; automatic, or cascade mode. In cascade, it shall be possible to configure remote setpoints from other regulatory controllers or from other control blocks.

d. There shall be bumpless transfer between all control modes, and windup protection shall be provided. Control blocks shall be able

to perform automatic mode switching based on external or internal logic inputs.

3. PIDE Integrated Auto-Tune

   a. An integrated PID auto-tuner should be built into the PIDE instruction used in the function block language. Because the PIDE auto-tuning is built into the system controllers, auto-tuning must be available from any operator workstation. Features shall include:

      1) Applicable to processes with slow and fast dynamics
      2) Used with self-regulating and integrating processes
      3) Immune to noise and process load disturbances
      4) Can be accessed directly from the controller

   b. The PID auto-tuning facility shall employ an easy-to-use graphical interface with a setup "wizard"(similar to Microsoft Excel®) to assist engineers and technicians who are unfamiliar with the tool.

4. PIDE Optimized Auto-Tune:

   a. The system shall provide advanced open and closed loop tuning and analysis by providing PID control loop optimization without additional programming.

   b. Software shall be furnished so that control loop process models can be automatically developed allowing users to analyze and simulate current operating conditions.

   c. An off-line modeling tool shall be available so archived process data can be used to perform loop analysis. Using real data off-line shall allow experimentation with new settings without compromising production.

5. Command Priorities: A scheme of priority levels shall be provided to prevent interaction of a command of low priority with a command of higher priority. Override commands entered by the operator shall have higher priority than those emanating from applications programs.

2.3 DEVELOPMENT SOFTWARE

A. All development of the software configuration shall be performed using hardware and the system software owned by the Instrumentation Supplier.