SECTION 13300 - PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 - GENERAL

1.01 WORK OF THIS SECTION

A. The CONTRACTOR shall provide all Process Control and Instrumentation Systems (PCIS) complete and operable, in accordance with the Contract Documents.

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

C. Responsibilities

1. The CONTRACTOR shall procure the services of a qualified PCIS Subcontractor approved by the ENGINEER for the implementation of the PCIS and the integration of the PCIS with other required instrumentation and control devices. As a minimum, the PCIS Subcontractor shall have the qualifications listed below. All qualifications shall be satisfied by the PCIS Subcontractor prior to the award.

a. The PCIS Subcontractor shall have been actively involved in the instrumentation, PLC based control systems, and SCADA systems business for a minimum of 7 years and shall have adequate facilities, organization structure, manpower, and technical and managerial expertise to properly perform the Work in conformance with these Specifications.

b. The PCIS Subcontractor shall have completed at least two instrumentation and control projects, each of which shall contain the following elements as a minimum:
   - 200 pieces of instruments
   - 10 control panels
   - 50 analog loops
   - Involved with upgrading a control system while the existing system was kept in operation
   - 5 programmable logic controllers (PLCs) implemented
   - 300 inputs/outputs to PLCs
   - Implementation of fiber optic communication cables
   - Implementation of Ethernet communication for process control
   - 3 PC/Workstations implemented
   - Implemented process control software
   - Implemented all software packages listed below
   - Value of the PLC, Human Machine Interface (HMI), and Supervisory Control and Data Acquisition (SCADA) software portion of the project not less than $100,000

c. Individuals furnishing office engineering and field testing, calibration, startup, and operator training services shall have appropriate experience
in similar responsible positions on similar instrumentation, PLC control, and computer system projects.

d. The PCIS Subcontractor shall be a firm which:

   i. Employs a minimum of two individuals who are proficient in the application of the most recent versions of the following operating systems:
      - Windows 2003 Server
      - Windows XP

   ii. Employs a minimum of two individuals who are proficient in the application of the following SCADA and Human Machine Interface (HMI) software packages. A minimum of 3 years experience is required.
      - Wonderware InTouch
      - Wonderware FactorySuite A2 Development (HMI graphics development software)
      - Wonderware Historian Version 9 (configuration software for the Historian server)
      - SCADA phoneNumber software (configuration software for the SCADA Alarm server)

   iii. Employs a minimum of two individuals who are proficient in programming Modicon Quantum PLCs using ProWorx32 and configuration of Modbus, Modbus Plus, Modbus TCP and Profibus networks. A minimum of 3 years experience is required.

   iv. Employs a minimum of two individuals who are proficient in the installation and configuration of Ethernet network equipment. A minimum of 1 year experience is required.

   v. Has been actively involved in the instrumentation systems business under the same corporate name of a minimum four years.

2. Within 14 days after the award of the Contract, the CONTACTOR shall submit to the ENGINEER a statement of qualifications of the proposed PCIS Subcontractor to demonstrate compliance with the qualifications requirements specified above. The statement of qualifications shall include the following:

   a. Firm name and contact person information, location of office(s)

   b. Age of firm, average number of employees over the past 5 years

   c. References for 3 similar projects. Include brief description of the project, Owner, organization, contact name, contact information (phone number, email address, street address, etc.). Identify the responder's key team members for the project, including their responsibility and duration of involvement with the project. Key project team members shall include project manager, project engineer, lead programmer (PLC and HMI), communications engineer, field installation supervisor, start-up personnel, training staff and other personnel as required.

   d. A list of projects that have been awarded in the last 5 years, including
brief project description, award date, final acceptance date and current status. For each project indicate approximate contract value.

e. Resumes indicating education, training, qualifications and availability of key employees proposed for the instrumentation design and programming activities

f. A joint venture of PCIS suppliers intending to pool resources between the joint venture members, such as the software expertise of one firm with the hardware design expertise of another firm. However, the joint venture shall act as under only one responsible management.

g. A letter from financial institution indicating current bonding limit and verifying ability to obtain performance bond for the value of the PCIS portion of this Project.

3. The proposed PCIS Subcontractor shall not be employed for the Project without the written approval of the ENGINEER. If, after review of the statement of qualifications, the ENGINEER should determine that the qualifications of the proposed PCIS Subcontractor do not meet the requirements specified herein, the CONTRACTOR shall submit the statement of qualifications of another PCIS Subcontractor that will meet the requirements at no additional cost to the OWNER.

4. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these specifications that the PCIS Subcontractor be responsible to the CONTRACTOR for the integration of the PCIS with existing devices and devices provided under other Sections with the objective of providing a completely integrated control system free of signal incompatibilities.

5. As a minimum, the PCIS Subcontractor shall perform the following work:

a. Implementation of the PCIS

i. Procure the SCADA software, computer and ancillary equipment. Install and configure the hardware and the Wonderware software, and program the screens for Operator Interface Station OIS 6.

ii. Revise all graphics on all existing SCADA screens (Domestic and Industrial Plants) using the latest symbols and drawing tools available.

iii. Add Store and Forward capabilities for historian data to the SCADA configuration. The current system configuration only has Failover capabilities.

iv. Procure the PLCs, program the control logic and the Operator Interface Terminal screens for new PLCs. Integrate vendor furnished PLCs in the SCADA network. Program additional logic and modify existing logic in existing PLCs. Refer to drawings I-01 and I-02 and the P&IDs for control requirements.

v. Prepare analog hardware submittals

vi. Design, develop, and electronically draft loop drawings and control panel designs

vii. Prepare the test plan, the training plan, and the spare parts
viii. Procure and install the instruments
ix. Fabricate panels
x. Perform factory tests on panels
xi. Perform bench calibration and verify calibration after installation
xii. Oversee and certify installation
xiii. Oversee, document, and certify loop testing
xiv. Oversee, document, and certify system commissioning
xv. Conduct the performance test
xvi. Prepare Technical Manuals
xvii. Conduct training classes
xviii. Prepare record drawings

b. Integration of the PCIS with instrumentation and control devices being provided under other Sections;
   i. Develop all requisite loop drawings and record loop drawings associated with equipment provided under other Divisions of these Specifications and OWNER furnished and existing equipment.
   ii. Resolve signal, power, or functional incompatibilities between the PCIS and interfacing devices.

6. Any PCIS Subcontractor responsibilities in addition to the list above are at the discretion of the CONTRACTOR and the PCIS Subcontractor. Additional requirements in this Section and throughout Division 13 which are stated to be the CONTRACTOR's responsibility may be performed by the PCIS Subcontractor if the CONTRACTOR and PCIS Subcontractor so agree.

D. Certification of Intent

1. Each bidder shall include with the bid the following Certification from the selected PCIS Subcontractor:
   a. The Certification shall be typed on the PCIS Subcontractor firm letterhead.
   b. It shall be signed by an authorized representative of the PCIS Subcontractor's firm.
   c. It shall include the following statements:
      i. [Corporate name of PCIS Subcontractor] "Hereby certifies intent to assume and execute full responsibility to the CONTRACTOR to perform all tasks defined under Paragraph 1.01.C.5 in full compliance with the requirements of the Contract Documents."
      ii. It is certified that the quotation to the CONTRACTOR includes full and complete compliance with the requirements of the Contract Documents without exception."

1.02 SUBMITTALS

A. General: Submittals shall be furnished in accordance with Section 01300 - Contractor
Submittals and the following:

1. The CONTRACTOR shall coordinate the instrumentation work so that the complete instrumentation and control system will be provided and will be supported by accurate shop drawings and record drawings.

2. Exchange of Technical Information: During the period of preparation of these submittals, the CONTRACTOR shall authorize a direct, informal liaison with the CONSTRUCTION MANAGER for exchange of technical information. As a result of this liaison, certain minor refinements and revisions in the systems as indicated may be authorized informally by the CONSTRUCTION MANAGER, but will not alter the scope of work or cause increase or decrease in the Contract Price. During this informal exchange, no oral statement by the CONSTRUCTION MANAGER shall be construed to give approval of any component or method, nor shall any statement be construed to grant exception to or variation from these Contract Documents.

3. Symbology and Nomenclature: In these Contract Documents, 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.

B. Presubmittal Conference

1. The CONTRACTOR shall arrange and conduct a Presubmittal Conference within 30 days after award of the contract. The purpose of the Presubmittal Conference is to review and approve the manner in which the CONTRACTOR intends to carry out its responsibilities for shop drawing submittal on the WORK to be provided under this Section. The CONTRACTOR, the PCIS Subcontractor, and the CONSTRUCTION MANAGER shall attend. Both the CONTRACTOR and the CONSTRUCTION MANAGER may invite additional parties at their discretion.

2. The CONTRACTOR shall allot two 8-hour days for the Conference.

3. The CONTRACTOR shall present the following for discussion at the Conference:
   a. A list of equipment and materials required for the PCIS and the Manufacturer's name and model number for each proposed item.
   b. A list of proposed clarifications to the contract documents along with a brief explanation of each. Resolution shall be subject to a separate formal submittal and review by the CONSTRUCTION MANAGER.
   c. An exact one-to-one sample of each type of submittal specified herein.
   d. A flow chart showing the steps to be taken in preparing and coordinating each submittal to the CONSTRUCTION MANAGER.
   e. A bar-chart type schedule for all system related activities from the Presubmittal Conference through start-up and training. Dates of submittals, design, fabrication, programming, factory testing, deliveries,
installation, field testing, and training shall be shown. The schedule shall be subdivided to show activities relative to each major item or group of items when everything in a given group is on the same schedule.

f. An overview of the proposed training plan. The OWNER's staff and CONSTRUCTION MANAGER will review the overview and may request changes. All changes to the proposed training shall be resolved at the pre-submittal conference. The overview shall include the following for each proposed course.

i. Course title and objectives.
ii. Prerequisite training and experience of attendees.
iii. Course content - a topical outline.
iv. Course duration.
v. Course format - lecture, laboratory demonstration, etc.

4. The CONTRACTOR shall furnish 3 copies of all the items above to the CONSTRUCTION MANAGER.

5. The CONTRACTOR shall take minutes of the Conference, including all events, questions, and resolutions. Prior to adjournment, all parties must concur with the accuracy of the minutes and sign accordingly.

C. Shop Drawings

1. General
   a. Preparation of shop drawings shall not commence until adjournment of the Presubmittal Conference.
   b. All shop drawings shall include the letterhead or title block of the PCIS Subcontractor. The title block shall include, as a minimum, the PCIS Subcontractor's registered business name and address, project name, drawing name, revision level, and personnel responsible for the content of the drawing. The quantity of submittal sets shall be as indicated in Section 01300 - Contractor Submittals.
   c. Organization of the shop drawing submittals shall be compatible with eventual submittals for later inclusion in the Technical Manual. Submittals not so organized and incomplete submittals for a given loop will not be accepted.
   d. Shop drawing information shall be bound in standard size, 3 ring, loose-leaf, vinyl plastic, and hard cover binders suitable for bookshelf storage. Binder ring size shall not exceed 3 inches.
   e. Interfaces between instruments, motor starters, control valves, variable speed drives, flow meters, chemical feeders and other equipment related to the PCIS shall be included in the shop drawing submittal.

2. Analog Hardware Submittal: The CONTRACTOR shall submit an analog hardware submittal as a complete bound package at one time within 60 calendar days after the commencement date stated in the Notice to Proceed, including:
   a. A complete index that lists each device by tag number, type, and
Manufacturer. A separate technical brochure or bulletin shall be included with each instrument data sheet. 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-S20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves, 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:

i. Component functional description used in the Contract Documents
ii. Manufacturer's model number or other product designation
iii. Project tag number used in the Contract Documents
iv. Project system or loop of which the component is a part
v. Project location or assembly at which the component is to be installed
vi. Input and output characteristics
vii. Scale, range, units, and multiplier (if any)
viii. Requirements for electric supply (if any)
ix. Requirements for air supply (if any)
x. Materials of component parts to be in contact with or otherwise exposed to process media and corrosive ambient air
xi. Special requirements or features

c. Flow meter sizing calculations. Calculations shall be submitted on the Instrument Manufacturer letterhead and shall include the following:

i. Proposed meter size based on indicated minimum, maximum and average flow rates
ii. Guaranteed meter accuracy based on the upstream and downstream straight runs associated with the location of each meter
iii. Permanent head loss associated with each meter
iv. Flow vs. differential pressure curves for all head-type devices. For compressible fluids, curves shall be pressure and temperature compensated.
v. References to ISA standard equations used
vi. Values used for all parameters used in calculations

d. Priced list of all spare parts for all devices

e. Instrument installation, mounting, and anchoring details shall be submitted in an electronic AUTOCAD and hard copy format. Each instrument type shall have a dedicated 11 by 17-inch detail which only pertains to the specific instrument type. Each instrument tag number shall
be listed and shall include detail information specific to that instrument. As a minimum, each detail shall have the following contents:

i. 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.

ii. Ambient temperature and humidity of the environment in which the instrument is to be installed.

iii. Corrosive qualities of the environment in which the instrument is to be installed.

iv. Hazardous rating of the environment in which the instrument is to be installed.

v. Process line pipe or tank size, service and material.

vi. Process tap elevation and location.

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

viii. Routing of tubing and identification of supports.

ix. Mounting brackets, stands, and anchoring devices.

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

xi. NEMA ratings of enclosures and all components.

xii. Clearances required for instrument servicing.

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

3. Project-Wide Loop Drawing Submittal: The CONTRACTOR shall furnish a Project-wide Loop Drawing Submittal (PLDS) that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop associated with equipment provided under Division 13 Sections, equipment provided under Sections in other Divisions, existing, and OWNER furnished equipment which is to be incorporated into the PCIS. The PLDS shall be a singular complete bound package electronically drafted in AUTOCAD, submitted within 120 days after contract award, and shall include the following:

a. A complete index in the front of each bound volume. The loop drawings shall be indexed by systems or process areas. All loops shall be tagged in a manner consistent with the Contract Documents. Loop drawings shall be submitted for every analog and discrete monitoring and control loop.

b. Drawings showing definitive diagrams for every analog and discrete instrumentation loop system. These diagrams shall show and identify each component of each loop or system using legend and symbols from ANSI/ISA S5.4 - Instrument Loop Drawings, extending the format as shown on Drawing GI-01 and as defined by the most recent revision in ISA. Panel drawings showing PLC input/output (I/O) card wiring and field terminations are not acceptable as loop drawings. Each system or loop diagram shall be drawn on a separate drawing sheet. Loop drawings shall be developed for loops in equipment vendor supplied packages,
equipment provided under Division 13, and OWNER furnished equipment. The loop drawings shall also show all software modules and linkages. In addition to the expanded ISA S5.4 requirements the loop diagrams shall also show the following details:

i. Functional name of each loop
ii. Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
iii. Motor control center (MCC) panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
iv. Designation, and if appropriate, terminal assignments associated with every manhole, pullbox, junction box, conduit, and panel through which the loop circuits pass.
v. Vendor panel, instrument panel, conduit, junction boxes, equipment and SCADA terminations, termination identification wire numbers and colors, power circuits, and ground identifications.

Itemized instrument summary. The summary shall be prepared with Microsoft Excel software and shall be submitted on a compact disk and hard copy. The instrument summary shall list all of the key attributes of each instrument provided under this Contract. As a minimum, attributes shall include:

i. Tag number
ii. Manufacturer
iii. Model number
iv. Service
v. Area location
vi. Calibrated range
vii. Loop drawing number
viii. Associated Local Control Panel, Programmable Logic Controller, Process Control Monitor, or Remote Terminal Unit

4. Test Procedure Submittals:

a. The CONTRACTOR shall submit the proposed procedures to be followed during tests of the PCIS and its components.

b. Preliminary Submittal: Outlines of the specific proposed tests and examples of proposed forms and checklists.

c. Detailed Submittal: After approval of the Preliminary Submittal, the CONTRACTOR shall submit the proposed detailed test procedures, forms, and checklists. This submittal shall include a statement of test objectives with the test procedures.

5. Training Submittals: Subsequent to the receipt of the OWNER's and CONSTRUCTION MANAGER's inputs made at the Presubmittal Conference, the CONTRACTOR shall submit a training plan which includes:

a. A resubmittal of the training plan overview from the Presubmittal Conference with incorporation of all modifications agreed upon at that meeting.
b. Schedule of training courses including dates, durations, and locations of each class.

c. Resumes of the instructors who will actually implement the plan.

D. Technical Manual

1. General: Information in the Technical Manual shall be based upon the approved shop drawing submittals as modified for conditions encountered in the field during the work.

2. The Technical Manual shall have the following organization for each process:
   a. Section A - Process and Instrumentation Diagrams
   b. Section B - Loop Descriptions
   c. Section C - Loop Drawings
   d. Section D - Instrument Summary
   e. Section E - Instrument Data Sheets
   f. Section F - Sizing Calculations
   g. Section G - Instrument Installation Details
   h. Section H - Test Results

3. Signed results from Loop Testing, Precommissioning, and Performance Testing shall be included in Section H.

4. Initially, 2 sets of draft Technical Manuals shall be submitted for review after return of favorably reviewed shop drawings and data required herein. Following the CONSTRUCTION MANAGER's review, one set will be returned to the CONTRACTOR with comments. The Manuals shall be revised and amended as required and the final Manuals shall be submitted 15 days prior to start-up of systems.

E. Record Drawings

1. The CONTRACTOR shall keep current a set of complete loop and schematic diagrams which shall include all field and panel wiring, piping and tubing runs, routing, mounting details, point-to-point diagrams with cable, wire, tube and termination numbers. These drawings shall include all instruments and instrument elements. One set of drawings electronically formatted in INTERGRAPH and 2 hard copies shall be submitted after completion of all Precommissioning tasks but prior to Performance Testing. All such drawings shall be submitted for review prior to acceptance of the completed work by the OWNER.

F. Software Design Document

1. General: The CONTRACTOR shall submit a software design document detailing the PLC programming and SCADA screen development. It shall be based on information from Division 13 specifications.

2. The document shall include the following, as a minimum:
1.03 COST LOADING AND CASH FLOW

A. General: The CONTRACTOR shall develop a schedule, schedule of values, and cash flow summary for inclusion as specified in these specifications elsewhere and/or Section 01310 – Progress Schedule. Failure to submit the schedule, schedule of values, or cash flow summary shall be because for withholding any progress payment due for instrumentation work under Sections in this Division.

B. Cash Flow Summary: The cash flow summary shall be based on the submitted Schedule and equal in total to the CONTRACTOR's instrumentation bid price plus approved contract modifications. Expected payment requests for each month shall be included, as well as the cumulative payment requests to date for each month of the project. The net payment requests for each month after deducting retainage and the cumulative payment requests to date shall also be shown.

1.04 SPECIAL WARRANTY REQUIREMENTS

A. Extended Period for Correction of Defects: The CONTRACTOR shall correct all defects in the PCIS upon notification from the OWNER within two years from the date of Substantial Completion. Corrections shall be completed within 5 days after notification.

PART 2 – PRODUCTS

2.01 GENERAL

A. Code and Regulatory Compliance: All PCIS WORK shall conform to or exceed the applicable requirements of the National Electrical Code. Conflicts between the requirements of the Contract Documents and any codes or referenced standards or specifications shall be resolved according to Section 01090 - Reference Standards.

B. Current Technology: All 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: All instruments which utilize a common measurement principle (for example, d/p cells, pressure transmitters, level transmitters which monitor hydrostatic head) shall be furnished by a single Manufacturer. All 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 a minimum accuracy of plus and minus 0.5 percent of full scale and a minimum repeatability of plus and minus 0.25 percent of full scale 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. All power supplies shall be mounted within control panels or in the field at the point of application.

F. Instrument Air: Dry, filtered control air at 30 pounds per square inch gauge (psig) nominal pressure shall be piped to all field instruments and instrument panels requiring air. Each field instrument shall be provided with an integral, non-adjustable filter/regulator assembly to provide regulated air. Each instrument panel requiring air shall be provided with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments. All air shall be filtered to 5 micron maximum particle size. Pressure reducers and regulators shall be furnished with additional instrumentation as required.

G. 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 wirewound 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.

H. Environmental Suitability: All 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 20% within the minimums and maximums of their rated environmental operating ranges. For example, if the most critical instrumentation device in the enclosure is the HMI with operating temperature limits between 32 and 131 degrees F, devices shall be provided to maintain the internal enclosure temperature between 39 and 105 degrees F. The CONTRACTOR shall provide all 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.
I. 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 milliamperes (mA) dc except as indicated. Signals within enclosures may be 1 to 5 volts dc. All electric signals shall be electrically or optically isolated from other signals. All pneumatic signals shall be 3 to 15 psig with 3 psig equal to 0 percent and 15 psig equal to 100 percent.

J. Control Panel Power Supplies: All control panels shall be provided with redundant power supplies which are configured in a fault-tolerant manner to prevent interruption of service upon failure and interruption of service necessitated by the replacement of a power supply. All power supplies shall have an excess rated capacity of 40 percent. The failure of a power supply shall be annunciated at the control panel and repeated to the SCADA System.

K. Alternative Equipment and Methods: Equipment or methods requiring redesign of any project details are not acceptable without prior written approval of the CONSTRUCTION MANAGER through the "or equal" process of the Bid Forms. 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.

2.02 OPERATING CONDITIONS

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

1. Environment - a wastewater treatment facility
2. Temperature Range - 32 through 120 degrees F
3. Thermal Shock - 1 degree F per minute, maximum
4. Relative Humidity - 20 through 90 percent, non-condensing

2.03 SPARE PARTS AND SPECIAL TOOLS

A. The CONTRACTOR shall furnish a list of recommended spare parts for field instrument, PLC components and miscellaneous panel components (e.g. power supplies and fuses) for the OWNER to select from.

B. The total price of selected spare parts shall not exceed $30,000 and shall be at the CONTRACTOR's expense.

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

2.04 FACTORY TESTING

A. The CONTRACTOR shall arrange for the Manufacturers of the equipment and fabricators of panels and cabinets supplied under this Section to allow the CONSTRUCTION MANAGER and OWNER to inspect and witness the testing of the equipment at the site of fabrication. Equipment shall include the cabinets, special control
PART 3 - EXECUTION

3.01 PRODUCT HANDLING

A. Shipping Precautions: After completion of shop assembly, factory test, and approval, all 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 job site.

B. 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 or other non-corrosive material tag firmly attached and permanently and indelibly marked 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 CONSTRUCTION MANAGER. If such tests reveal defects, the equipment shall be replaced.

3.02 INSTALLATION

A. General:

1. All instrumentation, including instrumentation furnished under other Divisions, shall be installed under Division 13 and the manufacturers' instructions.

2. Equipment Locations: The monitoring and control system configurations indicated 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. All 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. All conduit shall be provided under Division 16 without delay to the WORK of
   Division 13.

2. All 4-20 mA signal circuits, process equipment control wiring, signal wiring to field
   instruments, PLC input and output wiring and other field wiring and cables shall
   be provided under Division 16.

3. All PLC equipment cables shall be provided under Division 13.

4. All terminations and wire identification at PCIS equipment furnished under this or
   any other Division shall be provided under Division 13.

C. Instrumentation Tie-Downs: All instruments, control panels, and equipment shall be
anchored by methods which comply with seismic requirements which apply to the site.

D. Existing Instrumentation: Each existing instrument to be removed and reinstalled shall
be cleaned, reconditioned and recalibrated by an authorized service facility of the
instrument Manufacturer. The CONTRACTOR shall provide certification of this work
prior to reinstallation of each instrument.

E. Ancillary Devices: The Contract Documents show 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. All such additions and all such
changes, including the proposed method of installation, shall be submitted to the
CONSTRUCTION MANAGER for approval prior to commencing the work. Such
changes shall not be a basis of claims for extra work or delay.

F. Installation Criteria and Validation: All field-mounted components and assemblies shall
be installed and connected according to the requirements below:

1. Installation personnel have been instructed on installation requirements of the
   Contract Documents.

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

3. Installation personnel have at least one copy of the approved shop drawings and
data.

4. Instrument process sensing lines shall be installed similar to conduit specified
under Section 16050 – Electrical Work, General. Individual tubes shall run
parallel and near the surfaces from which they are supported. Supports shall be
used at intervals of not more than 3 feet of rigid tubing.
5. Bends shall be formed to uniform radii with the proper tool without deforming or thinning the walls of the tubing. Plastic clips shall be used to hold individual plastic tubes parallel. Ends of tubing shall be square-cut and cleaned before being inserted in the fittings. Bulkhead fittings shall be provided at all panels requiring pipe or tubing entries.

6. All differential pressure elements shall have three valve manifolds.

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

8. All power and signal wires shall be terminated with crimped type lugs.

9. All connectors shall be, as a minimum, water tight.

10. All wires shall be mounted clearly with an identification tag that is of a permanent and reusable nature.

11. All 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 CONSTRUCTION MANAGER. All wiring shall be protected from sharp edges and corners.

12. All mounting stands and bracket materials and workmanship shall comply with requirements of the Contract Documents.

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

14. The OWNER will not be responsible for any additional cost of rework attributable to actions of the CONTRACTOR or the PCIS Subcontractor.

3.03 CALIBRATION

A. General: All devices provided under Division 13 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 20, 40, 60, 80 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. Such adjustments, if required, shall be made only after consultation with the CONSTRUCTION MANAGER.

D. Field Calibration: Instruments that were not bench-calibrated shall be calibrated in the field to ensure 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. All 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 10, 50 and 90 percent of span
   9. Switch setting, contact action, and deadband for discrete elements
   10. Space for comments
   11. Space for sign-off by PCIS Subcontractor 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 CONSTRUCTION MANAGER. The CONTRACTOR shall have the PCIS Subcontractor sign the tag when calibration is complete. The CONSTRUCTION MANAGER will sign the tag when the calibration and testing has been accepted.

3.04 LOOP TESTING

A. General: Individual instrument loop diagrams per ISA S5.4 - Instrument Loop Diagrams, expanded format, shall be submitted to the CONSTRUCTION MANAGER for review prior to the loop tests. The CONTRACTOR shall notify the CONSTRUCTION MANAGER of scheduled tests a minimum of 30 days prior to the estimated completion date of installation and wiring of the PCIS. After the CONSTRUCTION MANAGER'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 CONSTRUCTION MANAGER.

B. Control Valve Tests: All 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. Interlocks: All hardware and software interlocks between the instrumentation and the
motor control circuits, control circuits of variable-speed controllers and packaged equipment controls shall be checked to the maximum extent possible.

D. Instrument and Instrument Component Validation: Each instrument shall be field tested, inspected, and adjusted to its indicated performance requirement in accordance its Manufacturer's specifications and instructions. Any instrument that 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 discretion of the CONSTRUCTION MANAGER.

E. Loop Validation: Controllers and electronic function modules shall be field tested and exercised to demonstrate correct operation. All control loops shall be checked under simulated operating conditions by impressing input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the PLC. Actual signals shall be used wherever available. Following any necessary corrections, the loops shall be retested. Specified accuracy tolerances for each analog network are defined as the root-mean-square-summation of individual component accuracy requirements. Individual component accuracy requirements shall be as indicated by Contract requirements or by published manufacturer accuracy specifications, whenever Contract accuracy requirements are not indicated. Each analog network shall be tested by applying simulated analog or discrete inputs to the first element of an analog network. For networks which incorporate analog elements, simulated sensor inputs corresponding to 20, 40, 60, 80 and 100 percent of span shall be applied, and the resulting element outputs monitored to verify compliance to calculated root-mean-square-summation accuracy tolerance requirements. Continuously variable analog inputs shall be applied to verify the proper operation and setting of discrete devices. Provisional settings shall be made on controllers and alarms during analog loop tests. All analog loop test data shall be recorded on test forms attached in Section 13320, Appendix A, which include calculated root-mean-square-summation system accuracy tolerance requirements for each output.

F. Loop Validation Sheets: The CONTRACTOR shall prepare loop confirmation sheets for each loop covering each active instrumentation and control device except 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 PCIS Subcontractor:

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. Loop description number
7. Adjustment check
8. Space for comments
9. Space for loop sign-off by PCIS Subcontractor and date

10. Space for CONSTRUCTION MANAGER witness signature and date

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

3.05 PRECOMMISSIONING

A. General: Precommissioning shall commence after acceptance of all wire tests, calibration tests and loop tests, and all inspections have demonstrated that the instrumentation and control system complies with all Contract requirements. Precommissioning shall demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.

B. Precommissioning Procedures and Documentation: All precommissioning and test activities shall follow detailed test procedures and check lists accepted by the CONSTRUCTION MANAGER. All test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the CONSTRUCTION MANAGER, which include calculated tolerance limits for each step. Completion of all system precommissioning and test activities shall be documented by a certified report, including all test forms with test data entered, delivered to the CONSTRUCTION MANAGER with a clear and unequivocal statement that all system precommissioning and test requirements have been satisfied.

C. Operational Validation: Where feasible, system precommissioning activities shall include the use of water to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, control panels, and ancillary equipment shall be tested under start-up and steady-state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. All hardwired and software control circuit interlocks and alarms shall be operational. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady-state operation of final control elements running under the control of field mounted automatic analog controllers or software based controllers shall be ensured by adjusting the controllers as required to eliminate oscillatory final control element operation. The transient stability of final control elements operating under the control of field mounted, and software based automatic analog controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations (if any) and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.

D. Loop Tuning: All electronic control stations incorporating proportional, integral or differential control circuits shall be optimally tuned, experimentally, by applying control
signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed setpoint settings shall be compared to measured final control element position/speed values at 20, 40, 60, 80 and 100 percent of span and the results checked against indicated accuracy tolerances.

E. Precommissioning Validation Sheets: Precommissioning shall be documented on one of two types of test forms as follows:

1. For functions which can be demonstrated on a loop-by-loop basis, the form shall include:
   a. Project name
   b. Loop number
   c. Loop description
   d. Tag number, description, manufacturer and data sheet number for each component.
   e. Space for sign-off and date by both the PCIS Subcontractor and CONSTRUCTION MANAGER.

2. For functions which cannot be demonstrated on a loop-by-loop basis, the test form shall be a listing of the specific tests to be conducted. With each test description the following information shall be included:
   a. Specification page and paragraph of function demonstrated
   b. Description of function
   c. Space for sign-off and date by both the PCIS Subcontractor and CONSTRUCTION MANAGER

F. Precommissioning Certification: The CONTRACTOR shall submit instrumentation and control system precommissioning completion report which shall state that all Contract requirements have been met and shall include a listing of all instrumentation and control system maintenance and repair activities conducted during the precommissioning testing. Acceptance of the instrumentation and control system precommissioning testing must be provided in writing by the CONSTRUCTION MANAGER before the performance testing may begin. Final acceptance of the control system shall be based upon plant completion as stated in the General Conditions.

3.06 ON-SITE SUPERVISION

A. The CONTRACTOR shall furnish the services of an on-site resident engineer to supervise and coordinate installation, adjustment, testing, and start-up of the PCIS. The resident engineer shall be present during the total period required to affect a complete operating system. A team of engineering personnel shall be on site for 80 hours to check all equipment, perform the tests indicated in this Section, and furnish startup services.

3.07 PERFORMANCE TEST

A. The entire PCIS shall operate for 30 days without failure.

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B. The CONTRACTOR shall furnish all necessary support staff as required to operate the system and to satisfy the repair or replacement requirements.

C. If any component fails during the performance test, it shall be repaired or replaced and the PCIS shall be restarted on another 30-day period.

3.08 TRAINING

A. General: The CONTRACTOR shall train the OWNER'S personnel on the maintenance, calibration and repair of all instruments provided under this Contract.

B. Instructions: The training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.

C. Duration: Each training class shall be a minimum of 8 hours in duration.

D. Schedule: Training shall be performed during the precommissioning phase of the project. The training sessions shall be scheduled a minimum of 3 weeks in advance of when the courses are to be initiated. The CONSTRUCTION MANAGER will review the course outline for suitability and provide comments that shall be incorporated.

E. Agenda: The training shall include, as a minimum, operational theory, operation and maintenance procedures, trouble shooting with necessary test equipment, repair, changing set points, and calibration for that specific piece of equipment.

F. Documentation: Within 10 days after the completion of each session the contractor shall submit the following:

1. A list of all OWNER personnel that attended the session.
2. An evaluation of OWNER personnel via written testing or equivalent evaluation.
3. A copy of the training materials used during the lesson with all notes, diagrams, and comments.

3.09 ACCEPTANCE

A. For the purpose of this Section, the following conditions shall be fulfilled before the WORK is considered substantially complete:

1. All submittals have been completed and approved.
2. The PCIS has been calibrated, loop tested and precommissioned.
3. The OWNER training has been performed.
4. All required spare parts and expendable supplies and test equipment have been delivered to the CONSTRUCTION MANAGER.
5. The performance test has been successfully completed.
6. All punch-list items have been corrected.
7. All record drawings in both hard copy and electronic format have been submitted.
8. Revisions to the Technical Manuals that may have resulted from the field tests have been made and reviewed.
9. All debris associated with installation of instrumentation has been removed.
10. All probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

- END OF SECTION 13300 -