

PIMA COUNTY REGIONAL WASTEWATER RECLAMATION DEPARTMENT
SCADA STANDARDIZATION PROJECT

TABLE OF CONTENTS

Section	Page
<u>DIVISION 13 - SPECIAL CONSTRUCTION</u>	
13401 SCADA System, General Requirements	13401-1
13402 SCADA System, Factory Testing	13402-1
13403 SCADA System, Start-up and Field Testing	13403-1
13404 SCADA System, Training	13404-1
13420 SCADA System, Primary Sensors and Field Instruments	13420-1
13430 SCADA System, Panels and Enclosures	13430-1
13440 SCADA System, Panel Instruments and Devices	13440-1
13451 SCADA System, Programmable Logic Controller, Hardware and Software	13451-1
13452 SCADA System, HMI Software and Hardware	13452-1
13460 SCADA System, Computers and Computer Networks	13460-1
13480 SCADA System, Input/Output List	13480-1
13491 SCADA System, Control Descriptions.....	13491-1
<u>DIVISION 16 - ELECTRICAL</u>	
16122 600-Volt Cable	16122-1

SECTION 13401
SCADA SYSTEM
GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE OF WORK

- A. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish, install, calibrate, test, start-up and place in satisfactory operation a complete Supervisory Control And Data Acquisition (SCADA) System. System shall be as specified in Division 13 and as shown. The system includes, but is not limited to the following major equipment:

NTS: DESIGN PROFESSIONAL SHALL INSERT AT NO. 1 THE LIST OF MAJOR ITEMS. DESIGN PROFESSIONAL COORDINATE WITH COUNTY'S INFORMATION TECHNOLOGY DEPARTMENT REGARDING ANY FIBER OPTIC INSTALLATION AND SPECIFICATIONS.

- 1. (--1--).
- B. SCADA System shall be designed to control, monitor, store, display and log process and equipment operating information and to perform various process control functions and generate various reports. The unit processes, which the SCADA shall monitor, and control are shown and described herein.
- C. Process and Instrumentation Diagrams (P&ID's) and Specifications of this Section and the other Applicable Instrumentation and Control Sections that illustrate and describe the overall SCADA System functional and operational requirements.

1.2 QUALITY ASSURANCE

- A. General:
 - 1. The SCADA System shall be furnished by a single Supplier who shall assume responsibility for providing a complete and integrated system.

2. All equipment, components and materials required shall be furnished by the single Supplier who shall assume the responsibility for adequacy and performance of all items.
3. The Supplier shall identify those system components, which are not of their manufacture.
4. The Supplier shall supply its company's Quality Assurance Plan, and for components that are not of its manufacture, the component manufacturer's Quality Assurance Plan. The plans shall include but not necessarily be limited to: method of testing, raw material criteria, methods of documentation, station control, "Burn-In", final tests and serialization coding and packaging.

 NTS: DESIGN PROFESSIONAL SHALL LIST ALL THE ITEMS, SUCH AS
 SUBMITTALS, O&MS ETC THAT ARE EXPECTED TO BE PROVIDED BY THE
 SYSTEM SUPPLIER IN ITEM 5.

5. The Supplier shall be responsible for all the items listed below:
 - i.

B. Supplier's Qualifications: Supplier shall;

1. Be a financially sound firm having at least five years continuous experience in designing, implementing, supplying and supporting instrumentation and control systems that are comparable to the SCADA System in terms of hardware, software, cost and complexity.
2. Have manufactured and supported standard lines of digital processing and control equipment and application software continuously for the last five years.
3. Have in existence at the time of bid advertisement, an experienced engineering and technical staff capable of designing, implementing, supplying and supporting the SCADA System and handling the SCADA System submittal and training requirements.
4. Provide system hardware components and software packages of fully developed, field proven standardized designs and therefore shall furnish a system that is not a highly unique, custom one-of-a-kind system.
5. Have a minimum of two years experience in hardware application and programming of distributed microprocessor based controllers and data highway systems.
6. Provide standard course offerings in general process control applications and in operation, programming and maintenance of the control system and equipment at a facility specifically utilized for training purposes. The facility shall have been in operation continuously for the last two years.
7. Have a thorough working knowledge of wastewater treatment processes and control philosophy in accordance with standard practices of the wastewater treatment industry.

8. Have a system of traceability of the manufactured units and purchased components through production, assembly and testing.
9. Have a system of "Burn-In" for all components and available supportive documentation.
10. Have a demonstrated record of prompt response to field failures.
11. Have a documented program of failure analysis.
12. Have or will use a UL approved panel shop.
13. Have a record of prompt shipments in accordance with contract obligations required for previous projects.

 NTS: IF SELECTION IS BASED ON CRITERIA, EDIT PARAGRAPH "C"
 ACCORDINGLY. FOR EXAMPLE, SOME PROJECTS MAY NOT REQUIRE SOME OF
 THE REQUIREMENTS. DELETE THE ONES NOT REQUIRED AND RENUMBER THE
 PARAGRAPHS BELOW. INSERT AT NO. 1 THE REQUIRED DAYS. THE DATE
 SHALL BE COORDINATED WITH THE DIVISION 0 AND DIVISION 1.

- C. Technical Proposal Requirements: The CONTRACTOR shall submit to OWNER a copy of a Technical Proposal from the Supplier which has been selected to provide the SCADA System. The Technical Proposal shall be submitted (--1--) days after the Notice to Proceed. The proposal shall be complete and contain all information as specified below.
1. Financial Statement: Include the value of distributed microprocessor based control systems delivered during the last two fiscal years. Also, include the value of other process instrumentation and controls shipped during the period.
 2. Experience:
 - a. Provide evidence of compliance with the specific experience requirements listed in Paragraph 1.2.B., above, in the form of an experience certification signed by an officer of the company.
 - b. Describe at least three completed municipal projects utilizing instrumentation and control equipment identical to or similar to (indicate which) that specified. Indicate owner, value, completion date, names and phone numbers of owner's representatives familiar with each project. Letters of recommendation may be submitted.
 - c. Furnish list of last ten projects completed.
 3. Personnel: Provide a listing of those personnel committed to be assigned to the Project. List shall include Project Manager, Project Engineer, Field Representative, local service representative, and sales representative. Indicate addresses of personnel not based at supplier's main office. Provide documentation including resumes of personnel demonstrating experience in wastewater treatment applications.
 4. Exceptions: List all exceptions and deviations from the requirements of these Specifications. Reference Section Number, Article, and Paragraph of proposed

variance and provide an explanation of why the proposed substitution meets (or exceeds) the functional or equipment requirements specified.

5. Shipment Records: Provide evidence of timely delivery of equipment on past projects.
6. SCADA Hardware and Software:
 - a. Provide a general system configuration drawing and include designations for model numbers and types of the proposed SCADA System and all other proposed system components.
 - b. Provide descriptive literature and manufacturer's catalog information covering all aspects of the hardware design, functions and capabilities of the specific system proposed for the SCADA System.
 - c. Describe standard software packages proposed, including any customized software required to meet the functional intent of the system specifications. Descriptions shall address the following:
 - 1) Overview of system software including the functions, organization and interrelationship of the major software modules provided.
 - 2) Estimated memory requirements to accomplish the specified graphic display, logging, reporting and alarming functional requirements.
 - 3) Examples of graphic displays, methods of display access and procedures for display definition and generation, including use of the standard symbols library and capabilities for generating and storing user defined symbols in the symbol library.
 - 4) Real-time data logging and reporting software features and capabilities including examples of logs and reports, procedures for automatic reporting and logging file setups, limitations on sampling and computing frequency for data acquisition and logging, and utilities for log file and report modifications and file maintenance.
 - 5) Alarm handling software features and capabilities including an alarm display example, methods of defining alarms and alarm files, automatic printing of alarms, acknowledgements and return to normal conditions, chronological sorting and time-tagging of alarms, and alarm file maintenance utilities.

NTS: IF THE PROGRAMMING OF THE PLC AND CONFIGURATION OF THE HMI SOFTWARE IS NOT PART OF THIS CONTRACT, THEN DELETE PARAGRAPH "6", OTHERWISE SELECT ONE OF THE THREE PARAGRAPHS BELOW.

- 6) Distributed system programming and documentation software features and capabilities, including screen display and printout examples for a fully annotated and cross-referenced ladder diagram and ladder and function block elements.

- 6) All PLC programs including database shall be provided to establish communication between the PLC and SCADA System that are provided independent of this Contract.
 - 6) All PLC programming and Human Machine Interface (HMI) software configuration documents, features and capabilities, including screen display and printout examples for a fully annotated and cross-referenced ladder function block diagram and the ladder and function block elements.
 - 7) Use of system level diagnostics for monitoring the performance of and detecting and reporting faults associated with the SCADA.
7. Panel Mounted Devices: Provide descriptive literature and catalog cuts for each type of sensor, transmitter, indicator, and other such devices required by the Project.
 8. Computer Network Hardware and Software:
 - a. Provide a general system configuration drawing and include designations for model numbers and types of the proposed network components.
 - b. Provide descriptive literature and manufacturer's catalog information covering all aspects of the hardware design and software functions.
 9. Training: Provide information and literature as to the organization proposed and the factory facilities to be utilized for the training specified. Indicate the qualifications of the factory training staff.
 10. Start-Up and Field Testing: Indicate how the Availability Demonstration will be accomplished.
 11. Maintenance: Provide the following information:
 - a. Location of service facility along with minimum and maximum response time.
 - b. Location of parts facility with delivery time and method.
- D. Supplier's Responsibility:
1. CONTRACTOR shall retain the SCADA System Supplier to undertake the responsibilities specified below. However, execution of these specified duties by the SCADA System Supplier shall not relieve CONTRACTOR of the ultimate responsibility for the SCADA System.
 - a. Design, fabrication, implementation and applications programming of the SCADA and all subsystems in accordance with the Contract Documents and all referenced standards and codes.
 - b. Preparation, assembly and correction of all SCADA System submittals in accordance with the Contract Documents.
 - c. Proper interfacing of the SCADA System hardware, software, field devices and panels, including required interfacing with packaged control systems furnished by other equipment suppliers, and with the plant electrical system.
 - d. Supervision of the installation of SCADA System, instruments, panels, consoles, cabinets, wiring and other components required.
 - e. Calibration, testing and start-up of the SCADA System.

- f. Training of OWNER’S personnel in operation and maintenance of the monitoring and control system.
- g. Handling of all warranty obligations for the control system components.
- h. Maintenance of two reproducible copies of the complete system and running software at the Supplier's facility for the duration of the warranty period. Software copies shall be maintained on the bulk storage medium used by the Supplier for system program development and shall be directly loadable on the supplied system.

 NTS: DELETE PARAGRAPH “i” IF NOT APPROPRIATE TO THE PROJECT.

- i. Programming of the PLC’s used in the SCADA System in accordance with the control description specified in the Contract Documents.

F. Reference Standards:

- 1. The following organizations have generated standards that are to be used as guides in assuring quality and reliability of components and systems; govern nomenclature; define parameters of configuration and construction, in addition to specific details in the Contract Documents:
 - a. The Instrumentation, Systems and Automation Society, (ISA).
 - b. National Institute of Standards and Technology, (NIST).
 - c. Underwriters' Laboratories, Inc., (UL).
 - d. American Water Works Association, (AWWA).
 - e. National Electrical Manufacturer’s Association, (NEMA).
 - f. Occupational Safety and Health Administration, (OSHA).
 - g. American National Standards Institute, (ANSI).
 - h. National Fire Protection Association, (NFPA).
 - i. Scientific Apparatus Manufacturer’s Association, (SAMA).
 - j. National Fire Protection Association 79, Annex “D” Standards, (NFPA).
 - k. Institute of Electrical and Electronic Engineers, (IEEE).
 - l. National Electrical Code, (NEC).

1.3 COORDINATION AND PROGRESS MEETINGS

- A. CONTRACTOR shall be responsible for scheduling and coordinating the system installation with regard to all other Work on the Site and in accordance with the provisions of the General Conditions. Said coordination shall be documented on the Project Schedule.

 NTS: INSERT AT NO. 1 THE REQUIRED NUMBER OF MEETINGS BELOW
 DEPENDING ON SIZE AND SCOPE OF PROJECT.

- B. Routine progress and coordination meetings will be scheduled by ENGINEER, CONTRACTOR and a representative of the SCADA System Supplier shall be required to attend a minimum of (--1--) meetings each month.
- C. The purpose of the meetings shall be to review the progress of the Work involving the SCADA System and provide coordination for installation of the equipment to ensure Project Schedule is met and to minimize disruption of current plant operations.
- D. Representatives at the meetings shall have the competence and authority to make any and all necessary decisions. Decisions and statements made at the meetings shall commit CONTRACTOR and System Supplier to agreed procedures and schedules.

1.4 SCADA SYSTEM SUPPLIER PROJECT PERSONNEL

- A. CONTRACTOR shall require the SCADA System Supplier to provide the following project personnel:

 NTS: THE REQUIRED NUMBER OF PERSONNEL SHALL BE DETERMINED BY THE
 SIZE AND SCOPE OF PROJECT.

- 1. Project Manager:
 - a. The System Supplier shall appoint a Project Manager who shall coordinate and schedule all the Work and assure that the Project Schedule is met.
 - b. The Project Manager shall act as the liaison with CONTRACTOR for the installation of the SCADA System equipment and shall assist in all matters required for proper coordination and interfacing of the equipment and processes.
- 2. Field Engineer:
 - a. The System Supplier shall appoint a Field Engineer with responsibilities as follows:
 - 1) Provide advice and technical consultation relative to installation techniques and procedures for equipment furnished.
 - 2) Installed system checkout, calibration, adjustment and start-up including tuning of every control loop.
 - 3) Maintenance services during availability demonstration.
 - 4) Involvement in the on-site system training of plant personnel.
 - 5) Resolving of control problems encountered during initial start-up and testing of all SCADA System equipment.
 - b. The Field Engineer shall have a minimum of five years experience in systems engineering and start-up and shall have a thorough working

knowledge of both the hardware and software supplied for the SCADA System.

NTS: DESIGN PROFESSIONAL SHALL INSERT THE CORRECT SPECIFICATION AT NO. 1.

- 3. Training Personnel:
 - a. Comply with requirements of Section 13404, SCADA System, Training, and Section (--1--), Instruction of Operators and Maintenance Personnel.

1.5 SUBMITTALS

- A. Shop Drawings:
 - 1. General:
 - a. Shop Drawing submittals shall be in accordance with the requirements of the Contract Documents.
 - b. Shop Drawings preparation shall not commence until after the Pre-Submittal Conference specified below.
 - c. Manufacture of the SCADA System shall not commence until related submittals have been approved by ENGINEER.
 - d. Shop Drawings shall be submitted in complete packages grouped to permit review of related items as generally outlined in Paragraph 1.5.A.3, below.
 - e. Review of Shop Drawings will be for conformance with Contract Documents and with regard to functions specified to be provided.
 - f. Final and approved copies of all Shop Drawings shall be provided in AutoCAD format on a CD-ROM.
 - 2. Pre-Submittal Conference:
 - a. CONTRACTOR shall arrange and conduct a Pre-Submittal Conference on the SCADA System within 45 days of notification of preliminary acceptance of the proposed SCADA System Supplier by OWNER and ENGINEER.

NTS: INSERT AT NO. 1 THE REQUIRED DAYS. INSERT AT NO. 2 THE RESPECTIVE REGIONAL OFFICE NAME.

- b. Pre-Submittal Conference shall be attended by representatives of CONTRACTOR, OWNER, the SCADA System Supplier, and ENGINEER. CONTRACTOR shall allot (--1--) full consecutive working days for the conference and that time shall be included in the price of this Contract. The meeting shall be held in OWNER'S (--2--) office.

- c. Purpose of the Pre-Submittal Conference shall be to review informally and accept the manner in which the SCADA System Supplier intends to respond to the requirements of the Contract Documents before any submittals are prepared.
 - d. CONTRACTOR shall prepare the items listed below for presentation at the Pre-Submittal Conference. The information shall be submitted to ENGINEER three weeks prior to the date of the conference.
 - 1) List of equipment and materials required for the SCADA System and the brand and model, which CONTRACTOR proposes to use for each item.
 - 2) List of proposed exceptions to the Contract Documents along with a brief explanation of each. Approval shall be subject to a formal submittal.
 - 3) Sample of each type of submittal specified herein. The samples may be submittals prepared for other projects.
 - 4) A flow chart showing the steps to be taken in preparing and coordinating each control system submittal to ENGINEER, and a list of proposed submittals.
 - 5) Gantt chart type schedule for all SCADA System related activities from the Pre-Submittal Conference through start-up and training. Particular emphasis shall be given to dates relative to submittals, design, fabrication, programming, factory testing, deliveries, installation and field-testing. 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. The schedule should be prepared using Microsoft Project.
 - 6) General outline of the type of tests to be performed to verify that all sensors/transducers, instruments and digital processing equipment are functioning properly.
3. Submittal Requirements:
- a. Product information for all sensors/transducers and field and panel instruments. Specification Forms for Process Measurement and Control Instruments, Primary Elements and Valves shall be submitted using ISA standard forms in accordance with ISA Standard S20, include the following:
 - 1) Manufacturer's product name, serial number and model number.
 - 2) Instrument tag number from Contract Documents.
 - 3) Manufacturers standard catalog product data.
 - 4) Description of construction features.
 - 5) Performance and operation data.
 - 6) Installation and mounting details, instructions and recommendations.
 - 7) Service requirements.
 - 8) Dimensions.
 - 9) Range of each device and calibration information.

- 10) Descriptions of materials of construction and a listing of NEMA ratings for all equipment.

NTS: SPECIFIER TO EDIT PARAGRAPH "b" AS APPROPRIATE TO MEET THE
TYPE OF PROJECT. CONFIGURED BY AN INTEGRATOR?

b. SCADA System Information:

- 1) System Description:
 - a) Detailed block diagram showing system hardware configuration and identifying model numbers of system components.
 - b) Software language and organization.
 - c) Format, protocol and procedures for data highway communications and local communications with input/ output modules and peripheral devices.
 - d) Human-machine interfacing details.
 - e) Control and failure modes.
 - f) On-line and off-line capabilities for programming, system utilities and diagnostics.
 - g) Input/output point listing with I/O module cross-reference identification for each distributed controller.
 - h) Data base listing including all input/output points.
 - i) Suggested detailed format and configuration of all log reports, alarm summaries, printer outputs, screen displays and graphics.
 - j) List of spare parts and test equipment.
- 2) Equipment Hardware:
 - a) Layout drawings showing front, rear, end and plan views to scale of all processing equipment, I/O components, power supplies and peripheral devices.
 - b) Construction details, features and procedures.
 - c) Interconnection diagrams including termination details, cable identification list and cable length.
 - e) Plans showing equipment layout in control panels.
 - f) Installation requirements, instructions and/or recommendations.
- 3) Software Description:
 - a) Standard technical documentation covering all aspects of the distributed control system software functions and capabilities, including instruction set description and programming procedures related to control, monitoring, display, logging, reporting and alarming functions.
 - b) Standard technical and instructional documentation covering software for utility, system support, system documentation, display, communications, data logging and storage and diagnostic functions.

- c) Detailed functional descriptions of application programs explaining control, display, logging and alarming features to be provided and functions to be performed.
 - d) Documentation describing memory type, size and structure and listing size of system memory, I/O and Data Table memory and size of memory available for control programs. Also, define estimated control program memory requirements and processor execution times and program scan times to perform the display, logging, reporting and alarm functions required.
 - e) Documentation describing central monitoring station main and secondary memory types, size and requirements to perform the display, logging, reporting and alarming functions required.
 - f) Documentation for all PLC programming and Human Machine Interface (HMI) software configuration including features and capabilities, screen display and printout examples of a fully annotated and cross-referenced ladder diagram and the ladder diagram elements.
 - g) Documentation of all PLC programs including the databases to establish communication between the PLC and SCADA System that are provided independent of this Contract.
- c. Panels, Consoles and Cabinets Information:
- 1) Layout Drawings include the following:
 - a) Front, rear, and internal panel views to scale.
 - b) Dimensional information.
 - c) Tag number and functional name of components mounted in and on panel, console or cabinet.
 - d) Product information on all panel components.
 - e) Nameplate location and legend including text, letter size and colors to be used.
 - f) Location of anchoring connections and holes.
 - g) Location of external wiring and/or piping connections.
 - h) Mounting and installation details.
 - i) Proposed layouts and sizes of graphic display panels.
 - j) Calculations for heating and cooling.
 - k) Subpanel layouts and mounting details for all items located inside control panels.
 - l) Calculations of estimated electrical power demand and expected run time of the Uninterruptible Power Supply (UPS).
 - 2) Wiring and/or piping diagrams include the following:
 - a) Name of panel, console or cabinet.
 - b) Wiring sizes and types.
 - c) Piping sizes and types.
 - d) Terminal strip numbers.
 - e) Color coding.

- f) Functional name and manufacturer's designation for components to which wiring and piping are connected.
- 3) Electrical control schematics in accordance with NFPA 79 Standards for all circuits indicated in the Contract Documents. No typical wiring diagrams will be acceptable and no tables or charts to describe wire numbers will be acceptable.
- 4) Stock list or Bill of Materials for each panel including tag number, functional name, manufacturer's name, model number and quantity for all components mounted in or on the panel or enclosure.
- d. Field piping diagrams include the following:
 - 1) Piping sizes and types.
 - 2) Location, functional name and manufacturer's designation of items to which piping is connected.
- e. Instrument loop diagrams for all analog display, control and I/O loops prepared using ISA standard symbols in accordance with ISA Standard S5.4, include the following:
 - 1) Instrument tag numbers from Contract Documents.
 - 2) Functional name of each item.
 - 3) Manufacturer's model, serial number, product, or catalog number for each item.
 - 4) Location of each item.
 - 5) Signal type and calibrated range, scale, and set point for each item, as applicable.
 - 6) Transmitter output drive and receiver input impedances. Show total loop impedance and reserve.
 - 7) Identification of all loop and instrument energy sources.
 - 8) Identification of all interconnections, include wire numbers, size and types, cable numbers, conduit numbers, intermediate junction box identification and location, terminal numbers, and grounding connections.

 NTS: DELETE PARAGRAPH "f" IF NOT REQUIRED.

- f. Computer Consoles:
 - 1) CONTRACTOR shall be responsible for coordinating the overall size of the console with the available floor space. A floor plan with all furniture, control panels, and the console system shall be produced by CONTRACTOR and submitted for review that includes all items specified herein.
 - 2) The console supplier shall provide design and application support by:
 - a) Determining the console functional design requirements. Coordinate with the relative equipment suppliers to ensure that all equipment specified to be mounted in console is installed

correctly in accordance with the manufacturer's recommendation.

- 3) Layout Drawings include the following:
 - a) Shall be prepared using AutoCAD.
 - b) Front, rear, end and plan views to scale.
 - c) Dimensional information.
 - d) Construction materials.
 - e) Product information on all console components.
 - f) Stock lists or Bill of Materials for each console.
 - g) Location of anchoring connections and holes.
 - h) Location of external wiring connections.
 - i) Mounting and installation details.
- 4) Panel internal point-to-point wiring diagrams, include the following:
 - a) Name of console.
 - b) Wiring sizes, types, and numbers.
 - c) Terminal strip and post numbers for all interconnections.
 - d) Color coding.
 - e) Functional name and manufacturer's designation for components to which wiring and piping are connected.
- 5) Submit samples of specified finish materials (work surface with nosing, available paint colors) to the ENGINEER for review and selection.
- 6) The Supplier of the console system shall be responsible for the sizing of the modular components to accommodate the computer equipment. This coordination shall be presented in the submittal.
- g. SCADA I/O Loop Wiring Diagrams: Prepare drawings on a module-by-module basis and include the following information:
 - 1) Rack numbers, slot number, module type and module terminal point numbers. Also, include location and identification of all intermediate panel terminal block and strip numbers to which I/O wiring and power supply wiring is connected. Identify all power supply circuit numbers and ratings.
 - 2) Wiring sizes, types, wire numbers and color-coding.
 - 3) Location, functional name, tag numbers and manufacturer model numbers of panel and field devices and instruments to which I/O wiring is connected. For discrete I/O devices use NFPA 79 electrical symbols tagged with designation as shown.

NTS: MODIFY TO MEET THE REQUIREMENTS OF THE PROJECT. PLC SYSTEM,
SCADA SYSTEM, CONFIGURATION BY THE SYSTEM SUPPLIER OR
INTEGRATOR, ETC.

- 4) Manufacturer's data sheets and catalog literature.

- 5) Description of on-line diagnostic tests and off-line tests.
 - 6) Dimensional data of equipment.
 - 7) Addressing card and system layout, including special configuration rules and limitations.
 - 8) Interface and cable data.
 - 9) Hardware manuals.
 - 10) Electrical characteristics and protection provided for each component.
 - 11) Indicated modularity of I/O modules.
 - 12) Manufacturer's installation instructions for grounding and power conditioning requirements.
 - 13) Description of how faults are detected, isolated and corrected.
- h. System Software Documentation: Prepare and submit two copies of preliminary software documentation at least four weeks prior to expected initiation of factory testing as specified in Section 13402, SCADA System, Factory Testing. Software documentation shall include the following as a minimum:
- 1) Complete hard copies of all ladder diagram and function block programming. Documentation shall include complete external and internal I/O coil, contact and signal cross-referencing, addressing and rung numbering. Documentation shall clearly distinguish between internal and real I/O and shall also incorporate extensive English language to identify contact, coil and signal functions and for labeling and description of program, sub-program and rung purpose and action.
 - 2) Complete listing of external and internal I/O address assignments, register assignments and preset constant values along with functional point descriptions. Also, list all unused/undefined I/O and data table registers available.
 - 3) Complete hard copies of all program documentation for all types of programs.
 - 4) Detailed system memory map defining memory segments used and spare memory segments available for system memory, I/O tables, Data Tables and control program.
 - 5) Complete database listing including listings for log, report and alarm file setups.
 - 6) Hard copies of all system graphic displays and formats for all logs, reports and the alarm summary.
 - 7) User's manuals describing procedures and providing examples for use of operator's consoles, workstations and programming terminal, accessories and system utility routines to perform control, display and logging program generation, program modification, program verification, diagnostics, program documentation, loading and backup and other required system support functions.

NTS: DESIGN PROFESSIONAL SHALL INSERT THE CORRECT SPECIFICATION AT
NO. 1.

B. System Operation and Maintenance Manuals:

1. Furnish Operation and Maintenance Manuals for the SCADA in accordance with Section (--1--), Operation and Maintenance Data and the supplemental requirements below:
2. The Operation and Maintenance Manuals shall include the following:
 - a. Name, address and telephone number of the SCADA Supplier's local service representative.
 - b. Complete list of supplied system hardware parts with full model numbers referred to system part designations, including spare parts and test equipment provided.
 - c. Copy of all approved submittal information and system Shop Drawings as specified herein with corrections made to reflect actual system as tested and delivered to the site for installation. Half-size black line reproductions shall be provided for all Shop Drawings larger than 11 by 17-inches.
 - e. Complete up-to-date system software documentation.
 - f. Manufacturer's Original Copies of Hardware, Software and Installation, Assembly and Operations Manuals for the distributed control system central monitoring stations, control panels, airconditioners and peripheral devices, and all other control system components. Manuals shall include the following information:
 - 1) General descriptive information covering the basic features of the equipment.
 - 2) Physical description covering layout and installation requirements and all environmental constraints.
 - 3) Functional and operational descriptions covering the procedures for programming, operation, start-up, shutdown, and calibration of the distributed control system equipment and explaining how the various control functions are performed.
 - 4) Principles of operation explaining the logic of operation; provide information covering operation to a component level.
 - 5) Maintenance procedures covering checkout, troubleshooting, and servicing; checkout procedures shall provide the means to verify the satisfactory operation of equipment, troubleshooting procedures shall serve as a guide in determining faulty components and servicing procedure shall cover requirements and recommended time schedule for calibration, cleaning, lubrication and other housekeeping and preventive maintenance procedures.
 - 6) Wiring, schematic and logic diagrams.
 - 7) Safety considerations relating to operation and maintenance procedures.

NTS: INSERT AT NO. 1 THE REQUIRED AMOUNT OF COPIES.

C. Record Drawings and Documentation:

1. CONTRACTOR and SCADA System Supplier shall revise all system Shop Drawings, submittals and software documentation to reflect as-built conditions in accordance with the requirements of the Contract Documents and the supplemental requirements below.
2. (--1--) copies of all revised Shop Drawings and documentation shall be submitted to the ENGINEER to replace out-dated drawings and documentation contained in the System Operation and Maintenance Manuals. Half-size black line sets shall be provided for all drawings larger than 11 by 17-inches. Specific instructions for out-dated drawing removal and replacement shall be provided with the Record Drawing submittal.
3. Half-size black line prints of wiring diagrams applicable to each control panel shall be placed inside a clear plastic envelope and stored in a suitable print pocket or container inside each control panel.
4. When applicable, updated electronic copies of Record Drawings and Documentation will be provided in AutoCadd or the original software.
5. A copy of all Division 13 training manuals shall be provided in Adobe Acrobat (pdf) format.

D. Reports:

1. Two copies of the following reports shall be submitted to ENGINEER:
 - a. Factory Test Reports if specified in Section 13402, SCADA System, Factory Testing.
 - b. Installation Inspection, Field Calibration, and Field Testing Reports as specified in Section 13403, SCADA System, Start-up and Field Testing.

1.6 EQUIPMENT DELIVERY, HANDLING AND STORAGE

NTS: DESIGN PROFESSIONAL SHALL INSERT THE CORRECT SPECIFICATIONS AT NO.S 1 AND 2.

- A. CONTRACTOR shall make all arrangements for transportation, delivery and storage of the equipment and materials in accordance with Section (--1--), Transportation and Handling of Products, requirements of the system Supplier, and requirements of equipment manufacturers.
- B. SCADA equipment shall be packaged at the factory prior to shipment to protect each item from damage during shipment and storage. Containers shall be protected

against impact, abrasion, corrosion, discoloration and/or other damages. Clearly label contents of each container and provide information on the required storage conditions necessary for the equipment.

- C. CONTRACTOR shall make arrangements to store SCADA equipment in accordance with Section (--2--), Storage and Protection of Products, and manufacturer's instructions and relevant organization standards. System Supplier shall notify CONTRACTOR, in writing, with copies to OWNER and ENGINEER of the storage requirements and recommendations for the equipment prior to shipment.

1.7 GENERAL DESIGN REQUIREMENTS

A. Power Supplies:

1. All electrically powered equipment and devices shall be suitable for operation on 115 volt ± 10 percent, 60 Hz ± 2 Hz power. If a different voltage or closer regulation is required, a suitable regulator or transformer shall be provided.
2. Appropriate power supplies shall be furnished by CONTRACTOR for all two wire transmitters, loops for monitoring discrete inputs and all necessary outputs. Power supplies shall be mounted in enclosures and installed in the appropriate control room or field panel.
3. Design all power supplies for a minimum of 130 percent of the maximum simultaneous current draw.
4. Furnish a power on-off switch or an air circuit breaker for each item requiring electrical power.
5. Provide isolation transformers, line voltage regulators and power distribution panels for the distributed digital portions of the SCADA System to eliminate electrical noise and/or transients entering on the primary power line.

B. Signal Requirements:

1. The control system shall be designed to use 4 to 20 mA DC analog signals, unless otherwise specified.
2. Provide signal converters and repeaters where required. Analog inputs to the distributed control system shall be through appropriate repeaters to provide signal isolation where series looped with other devices and to allow the loop to maintain integrity even if the SCADA system is out of service. Power supplies shall be sized adequately for signal converter and repeater loads.
3. Signals shall be isolated from ground.
4. Signals shall not have a transient DC voltage exceeding 300 volts over one millisecond nor a DC component over 300 volts.
5. The system and associated input/output wiring will be used in a plant environment where there can be high energy AC fields, DC control pulses, and varying ground potentials between the sensors/transducers or input contact locations and the system components. The system design shall be adequate to provide proper protection against interferences from all such possible situations.

6. All panels are to provide separate grounding terminals for signal ground and signal shields.
7. All field dry contacts (sourced by 120 VAC from each PLC control cabinet) shall not be neutral switched.
8. Remotely powered 120 VAC field signaling shall be isolated via an interposing 120 VAC relay within the PLC control cabinet.

C. Miscellaneous:

1. All instrumentation and SCADA System components shall be heavy-duty types, designed for continuous service in a municipal wastewater treatment plant environment. The system shall contain products of a single manufacturer, when possible, and consist of equipment models that are currently in production. All equipment provided shall be of modular construction and be capable of field expansion through the installation of plug-in circuit cards and additional cabinets as necessary. Design all logic and control loops to fail-safe.
2. All instrumentation and SCADA System components shall be designed to return automatically to accurate measurement within 60 seconds upon restoration of power after a power failure or when transferred to standby power supply or within limit stated by equipment manufacturer.
3. Surge protection shall be provided for all instruments and all other SCADA System components that could be damaged by electrical surges.
4. All field-mounted instruments and SCADA System components shall be designed for installation in humid and corrosive service conditions. All field mounted instrument enclosures, junction boxes and appurtenances shall conform to NEMA 4X requirements, unless otherwise specified.
5. All relays with interconnections to field devices shall be wired through terminal blocks. Terminals as part of the relay base are not an acceptable alternate.
6. All panel mounted instruments, switches, and other devices shall be selected and arranged to present a pleasing coordinated appearance. All front of panel mounted devices shall be of the same manufacturer and model line.
7. All components furnished, including field and rear of panel instruments, shall be tagged with the item number and nomenclature as shown on the Contract Documents.
8. Ranges and scales specified herein shall be coordinated to suit equipment actually furnished.
9. Field-mounted devices shall be treated with an anti-fungus spray.
10. Field-mounted devices shall be protected from exposure to freezing temperatures.

D. Environmental Conditions:

1. The control system shall be designed and constructed for continuous operation under the following temperature and humidity conditions:
 - a. Control Rooms:
 - 1) Ambient Temperature: 60°F to 80°F normal range; 40°F to 105°F occasional maximum extremes.

- 2) Relative Humidity: 80 percent, normal; 95 percent maximum.
- b. Indoor locations for digital processing equipment hardware, control panels and instruments:
 - 1) Ambient Temperature: 40°F to 120°F.
 - 2) Relative Humidity: 98 percent maximum.
- c. Outdoor locations for instruments:
 - 1) Ambient Temperature: -10°F to 120°F.
 - 2) Relative Humidity: 100 percent maximum.

E. System Designs:

1. Range, scale and set point values specified in other applicable Division 13 sections are for initial setting and configuration. Coordinate to these values with actual equipment furnished to implement proper and stable process action as systems are placed in operation.
2. For any items where ranges, scales and set points may not have been specified, CONTRACTOR shall submit a recommendation to ENGINEER for review.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

++ END OF SECTION ++

SECTION 13402

SCADA SYSTEM
FACTORY TESTING

PART 1 - GENERAL

1.1 SCOPE

- A. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to perform factory testing, before shipment, at the manufacturer's facility to verify that system components are functioning properly and that they meet the functional and performance requirements of the Contract Documents. The system includes, but is not necessarily limited to, the following major equipment.

NTS: DESIGN PROFESSIONAL SHALL INSERT AT NO. 1 CONTROL PANEL NAMES THAT REQUIRE A FACTORY TEST. INCLUDE CONFIGURED HMI SOFTWARE IF NECESSARY.

- 1. (--1--).
- B. CONTRACTOR shall submit information on factory testing procedures to verify that testing shall fulfill the requirements as specified herein. Submittal to ENGINEER shall be made at least two months in advance of any scheduled testing and shall include dates of scheduled tests.
- C. CONTRACTOR shall notify ENGINEER, in writing, at least four weeks before expected initiation of tests. OWNER and ENGINEER may elect to be present at CONTRACTOR'S facilities during operational test of system equipment, either for individual units or as an integrated system. Presence of OWNER and ENGINEER during testing does not relieve CONTRACTOR from conforming to the requirements of the Contract Documents and shall in no way imply acceptance of the equipment.
- D. Factory Testing shall not begin until all related Supervisory Control And Data Acquisition (SCADA) System shop drawings have been submitted and approved.

NTS: DESIGN PROFESSIONAL SHALL INSERT AT NO. 1 THE NUMBER OF
OWNER'S REPRESENTATIVES WHO WILL BE ATTENDING THE FACTORY
ACCEPTANCE TESTS.

- E. CONTRACTOR shall be responsible for the expenses associated with {--1--} of the OWNER's representatives attending the Factory Acceptance Test.

1.2 INSPECTION

- A. All panels, consoles and cabinets shall be inspected. Inspection shall include, but not be limited to, the following:
 1. Nameplates and tags.
 2. Wire sizes and color coding.
 3. Terminal block contact ratings and numbers.
 4. Annunciator and terminal block spares.
 5. Proper wiring practices and grounding.
 6. Enclosure flatness, finish and color.

1.3 SYSTEM HARDWARE OPERATIONAL TESTING

- A. All input/output devices and components shall be tested to verify operability and basic calibration.
- B. All system hardware components shall be tested to verify proper operation of the equipment as stand alone units. Tests shall include, but not be limited to, the following:
 1. AC/DC power checks.
 2. Power fail/restart tests.
 3. Diagnostics checks.
 4. Test demonstrating that all specified equipment functional capabilities are working properly.
- C. All PLC input/output devices shall be tested to verify proper operation and basic calibration. CONTRACTOR shall test all input and output points prior to the witnessed factory test and shall provide copies of signed and certified check lists or other documentation to demonstrate the completion of I/O testing. A random sampling of I/O (both digital and analog), in an amount approximately equal to five percent of the total I/O count, shall be selected by ENGINEER and tested during the witnessed factory test. PLC I/O testing shall include, as a minimum, the following:
 1. Simulate a field digital input for each PLC input point at the terminal strip of the control panel and verify PLC response.
 2. Simulate a field analog input for each PLC analog input point at the terminal strip of the control panel and verify PLC response.
 3. Force an output for each PLC digital output point and verify the signal presence at the terminal strip in the control panel.

- 4. Simulate an analog output for each PLC analog output point and verify signal presence at the terminal strip in the control panel.
- D. All system components shall be tested to verify that communication between units is working properly.
- E. An integrated system test with all system equipment connected (excluding field sensors and instruments) shall be performed to verify that all equipment is performing properly as an integrated system.

 NTS: DESIGN PROFESSIONAL SHALL EDIT ARTICLE "1.4" TO MEET THE REQUIREMENTS OF THE PROJECT. THIS SECTION SHOULD ALSO BE CHANGED TO ADD COORDINATION WITH A COUNTY SYSTEM INTEGRATOR, IF APPLICABLE.

1.4 SYSTEM SOFTWARE DEMONSTRATION

- A. CONTRACTOR shall demonstrate all system software utility and security programs incorporated into the system to illustrate the various functions and capabilities specified.
- B. CONTRACTOR shall demonstrate the operation and display of all software based on a simulation of five percent of total input/output count, both analog and discrete, as selected by the manufacturer. In addition, OWNER/ENGINEER shall randomly select, at the time of the test, additional inputs and outputs to be simulated in an amount approximately equal to five percent of total input/output count. Demonstration shall show that the monitoring and control application software associated with the input/output points performs the functions intended.
- C. System performance shall be tested using a fully integrated system, including all software and hardware if applicable. To achieve this, the entire control system, including all the peripheral devices and all interconnecting cables, shall be assembled on the factory test floor and simulated inputs applied. CONTRACTOR shall carry out a full system test, during which the entire system shall operate continuously without failure in accordance with the requirements of the Contract Documents. CONTRACTOR shall provide process I/O simulation panel prior to the test:
 - 1. Toggle switches to simulate field or other input contacts.
 - 2. Indicating lights to simulate outputs from tested panels.
 - 3. Control relays to simulate MCC coil inputs.
 - 4. Time relays to simulate position switches.
 - 5. Indications (Ma) to indicate every 4 to 20 mADC output from tested panel.
 - 6. Potentiometers to simulate 4 to 20 mADC inputs to tested panel.
 - 7. Every device shall have a nameplate containing the device under test's P&ID tag number and description. Nameplates shall be removable and interchangeable for reuse of the I/O simulator panel during the progression of the testing.

- D. Demonstration of communication between processors or to remote I/O units shall be included in the Test Procedure, where applicable.
- E. Operator Interfaces: Prior to the staging and testing of the system, the display environments shall have been configured in accordance with the agreed upon display structure, loaded and data base parameters linked to the specified fields. During this phase of the factory acceptance test, the overall display structure shall be demonstrated, including environment configurations, passwords, security, etc. The memo display contents shall be reviewed to demonstrate how an operator navigates within the overall display structure. The assignment of displays to annunciator keys shall also be demonstrated. Each graphic display shall be reviewed for correctness in terms of the layout, symbols, color scheme, etc. The operation of standard alarm management displays (Current Alarm Display, Alarm History, etc.) shall also be demonstrated. A demonstration of each type of report specified shall be performed. Printing shall be an integral part of the report demonstration.

1.5 FACTORY TEST REPORTS

- A. Panel, software and control component modifications and corrections required as a result of testing shall be completed and documented before shipment. Panels shall not be shipped from the factory, until two (2) copies of certified Factory Test reports indicating satisfactory performance have been submitted to and approved by ENGINEER. Factory Test reports shall include the following information:
 - 1. List of tests performed.
 - 2. Certified check lists or documentation verifying all I/O has been tested, as specified above.
 - 3. Documentation verifying all panel wiring has been checked.
 - 4. List of required modifications or corrections identified during the Factory Test and corrective action taken.
 - 5. Factory test reports shall be signed and dated by an authorized representative of the System Supplier and CONTRACTOR.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

++ END OF SECTION ++

SECTION 13403

SCADA SYSTEM
START-UP AND FIELD TESTING

PART 1 - GENERAL

1.1 SYSTEM CHECK-OUT AND START-UP RESPONSIBILITIES

- A. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install all equipment and coordinate all activities necessary to perform check-out and start-up of the equipment.

NTS: DESIGN PROFESSIONAL SHALL EDIT SECTION B BASED ON COMPLEXITY
OF THE PROJECT AND THE NUMBER AND TYPE OF INSTRUMENTS PROVIDED
WITH THE PROJECT.

- B. CONTRACTOR shall retain the services of the SCADA System Supplier to supervise and/or perform check-out and start-up of all system components. As part of these services, the System Supplier shall include for those equipment items not manufactured by him the services of an authorized manufacturers' representative to check the equipment installation and place the equipment in operation. The manufacturers' representative shall be thoroughly knowledgeable about the installation, operation and maintenance of the equipment.

1.2 SYSTEM CHECKOUT AND START-UP

- A. CONTRACTOR, under the supervision of the SCADA System Supplier, and other instrument suppliers as applicable, shall perform the following:
 - 1. Check and approve the installation of all SCADA System components and all cable and wiring connections between the various system components prior to placing the various processes and equipment into operation.
 - 2. Conduct a complete system checkout and adjustment, including calibration of all instruments, tuning of control loops, checking operation functions, and testing of final control actions. When there are future operational functions included in this work, they should be included in the system checkout. All problems encountered shall be documented and promptly corrected to prevent any delays in start-up of the various unit processes.

- B. CONTRACTOR shall provide all test equipment and software necessary to perform the testing during system checkout and start-up. CONTRACTOR shall transfer all test equipment and software to the OWNER after all final testing and commissioning.
- C. CONTRACTOR and SCADA System Supplier shall be responsible for initial operation of monitoring and control system and shall make any required changes, adjustment or replacements for operation, monitoring and control of the various processes and equipment necessary to perform the functions intended.
- D. CONTRACTOR shall furnish to the ENGINEER certified calibration reports for field instruments and devices specified in Section 13420, SCADA System, Primary Sensors and Field Instruments, and panel mounted devices specified in Section 13440, SCADA System, Panel Instruments and Devices, as soon as calibration is completed.
- E. CONTRACTOR shall furnish ENGINEER an installation inspection report certifying that all equipment has been installed correctly and is operating properly. The report shall be signed by authorized representatives of both CONTRACTOR and the Supplier.
- F. CONTRACTOR shall provide all software and licenses required to operate, troubleshoot, maintain and repair all systems provided under this contract.

1.3 INTEGRATED SYSTEM FIELD TEST

- A. Following the SCADA System checkout and initial operation, CONTRACTOR, under the supervision of the SCADA System Supplier, shall perform a complete system test to verify that all equipment and programmed software is operating properly as a fully integrated system, and that the intended monitoring and control functions are fully implemented and operational. Any defects or problems found during the test shall be corrected by CONTRACTOR and then retested to demonstrate proper operation.
- B. Following demonstration of all system functions, the SCADA System including field sensors/transducers and instruments shall be running and fully operational for a continuous 48 hour period. The Operational Availability Demonstration specified below shall not begin until the continuous 48 hour integrated system test has been successfully completed and OWNER and ENGINEER agree that the Operation Availability Demonstration can begin.

1.4 OPERATIONAL AVAILABILITY DEMONSTRATION

 NTS: DESIGN PROFESSIONAL SHALL EDIT AVAILABILITY AND DURATION TO
 SUIT THE PROJECT.

- A. Operational Availability Demonstration (OAD) shall begin following completion of the integrated system field test as specified above and shall continue until a time frame has been achieved wherein the system (both hardware and software) availability meets or exceeds 99.7 percent for 60 consecutive days and no system failures have occurred which result in starting the OAD over again. During the OAD the system shall be available to plant operating personnel for use in normal operation of the plant.
- B. For the purpose of the OAD, the system will be defined as consisting of the following systems and components:

 NTS: DESIGN PROFESSIONAL SHALL INSERT MAJOR COMPONENTS AT NO. 1.

- 1. (--1--).

- C. The conditions listed below shall constitute system failures which are considered critical to the operability and maintainability of the system. The OAD shall be terminated if one or more of these conditions occur. Following correction of the problem, a new 60 consecutive day OAD shall begin.
 - 1. Failure to repair a hardware or software problem within 120 consecutive hours from the time of notification of a system failure.
 - 2. Recurrent hardware or software problems: if the same type of problem occurs three times or more or different problems occur to the same hardware or process.
 - 3. Software problem causing a processor to halt execution or malfunction.
- D. The following conditions shall constitute a system failure in determining the system availability based on the equation specified in Paragraph 1.4.E., below:

 NTS: DESIGN PROFESSIONAL SHALL INSERT MAJOR COMPONENTS AT NO. 1 AND EDIT ITEM 7 AS NECESSARY.

- 1. Failure of (--1--).
- 2. Loss of communications between devices on the communications network.
- 3. Failure of one or more input/output components.
- 4. Failures of any type affecting eight or 50 percent of any PLC IO card or more input/output points simultaneously.
- 5. Failure of any type affecting one or more regulatory control loops or sequential control strategies thereby causing a loss of the automatic control of the process variable or process sequence operation.
- 6. Failure of power supply. Where redundant power supplies are provided, failure of one power supply shall not constitute a system failure provided the backup power supply operates properly and maintains supply power. Failure of the

backup supply to operate properly and maintain supply power shall constitute a system failure.

7. Failure of three or more primary sensors/transducers or field instruments simultaneously.

- E. The system availability shall be calculated based on the following equation:

$$A = \frac{TTO}{TTO + TTR} \times 100 \text{ percent}$$

where, A = system availability in percent

TTO = total time in operation

TTR = total time to repair

- F. Time to repair shall be the period between the time that CONTRACTOR is notified of a system failure and the time that the system has been restored to proper operation in terms of hours with an allowance for the following dead times which shall not be counted as part of the time to repair period.
1. Actual travel time for service personnel to get to the Site up to six hours per incident from the time CONTRACTOR is notified of a system failure.
 2. Time for receipt of spare parts to the plant site once requested up to 24 hours per incident. No work shall be done on the system while waiting for delivery of spare parts.
 3. Dead time shall not be counted as part of the system available period. The dead time shall be logged and the duration of the OAD extended for an amount of time equal to the total dead time.
- G. Completion of a 60 consecutive day period without any restarts of the OAD and with a System availability in excess of 99.7 percent will constitute acceptance of the SCADA System by OWNER.
- H. All parts and maintenance materials required to repair the system prior to completion of the OAD shall be supplied by CONTRACTOR at no additional cost to OWNER. If parts are obtained from the required plant spare parts inventory, they shall be replaced to provide a full complement of parts as specified.
- I. A SCADA System Malfunction/Repair Reporting Form shall be completed by the plant personnel and ENGINEER to document system failures, to record CONTRACTOR notification, arrival and repair times and CONTRACTOR repair actions. Format of the form shall be developed and agreed upon prior to the start of the OAD.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

++ END OF SECTION ++

SECTION 13404

SCADA SYSTEM
TRAINING

PART 1 - GENERAL

1.1 REQUIREMENTS AND RESPONSIBILITIES

- A. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to perform and coordinate all required training at times acceptable to OWNER and ENGINEER. No part of the training shall be construed as a substitution for complete and comprehensive Operations and Maintenance (O&M) manuals, but should follow the same organizational structure as the O&M manuals.
- B. CONTRACTOR shall retain the services of the SCADA System Supplier to provide operation and maintenance training for all SCADA equipment as specified herein.
- C. For equipment items not manufactured by the Supplier, the Supplier shall provide for on-site training by an authorized representative of the equipment manufacturer as part of the Supplier's services. The manufacturer's representative shall be fully knowledgeable in the operation and maintenance of the equipment.

NTS: DESIGN PROFESSIONAL SHALL INSERT AT NO. 1 THE REQUIRED NUMBER
OF PEOPLE.

- D. CONTRACTOR shall be responsible for all costs, including cost of travel, meals and lodging, for training OWNER personnel if required, associated with training, both on-site and at the Supplier's facilities, and shall provide all required materials, texts and required supplies. A total of (--1--) will be attending training courses at the Supplier's facility.
- E. All training shall be conducted to meet the needs of the OWNER personnel during all shifts. For training at the Supplier's facility, the course instructor shall be assigned full time and shall not perform other duties throughout the period of the course.

1.2 SUBMITTALS

NTS: INSERT AT NO. 1 REQUIRED NUMBER OF DAYS (DEPENDING ON SIZE AND SCOPE OF PROJECT). INSERT THE APPROPRIATE SECTION NUMBER AT NO. 2.

- A. Within (--1--) days of the effective date of the Notice to Proceed, CONTRACTOR shall submit his plan for training conforming to the requirements of Section (--2--), Instruction of Operations and Maintenance Personnel. Included in the plan shall be course outlines and schedules for training to be provided at the Supplier's facilities.

NTS: DELETE ARTICLE "1.3" IF NOT REQUIRED.

1.3 TRAINING AT THE SUPPLIER'S FACILITY

- A. General:
 - 1. CONTRACTOR shall provide a Supplier who shall perform standardized, structured training courses at an established training facility staffed with regular full time training instructors covering both operation and maintenance of the system equipment furnished by the Supplier.
 - 2. All training shall be scheduled so that it has been completed prior to the start of the factory testing of the system.

NTS: DESIGN PROFESSIONAL SHALL INSERT AT NO. 1 AND NO. 2 THE REQUIRED NUMBER OF PEOPLE. COORDINATE WITH PARAGRAPH "1.1.D."

- 3. OWNER will send the following personnel to attend training courses at the Suppliers facilities.
 - a. SCADA Systems Training: (--1--) persons.
 - b. SCADA System Maintenance Training: (--2--) persons.

NTS: INSERT AT NO. 1, THE NUMBER OF DAYS. INSERT AT NO. 2 THE EQUIPMENT COVERED IN THE TRAINING.

- B. SCADA System Training Course:
 - 1. Provide a (--1--) days, eight hours per day, course covering the structure and the functions of the (--2--) and other system components and devices. The course shall familiarize the student with the procedures for applying the system to process control problems and develop student programming capability.
 - 2. As a minimum, the course shall cover the following topics:
 - a. Overview of systems functional capabilities.

- b. Equipment overview including system component functions, operating principals and proper use.
- c. Loading and start-up of the digital system hardware components.
- d. Use of system commands and entering set points.

 NTS: DESIGN PROFESSIONAL SHALL EDIT THE FOLLOWING SECTION AS
 REQUIRED. INSERT THE CORRECT SPECIFICATION SECTION AT NO. 1.

1.4 ON-SITE TRAINING

- A. Primary Sensors/Transducers and Field Instruments:
 - 1. Provide on-site operation and maintenance training by Supplier and the equipment manufacturer representatives prior to placing the equipment in continuous operation, conforming to the requirements of Section (--1--), Instruction of Operations and Maintenance Personnel. The services of equipment manufacturer's representatives shall be provided for a minimum of eight hours for each type of instrument provided.
 - 2. Training shall accomplish the following:
 - a. Provide instruction covering use and operation of the equipment to perform the intended functions.
 - b. Provide instruction covering procedures for routine, preventive and troubleshooting maintenance including equipment calibration.
 - c. Explain procedures for placing the equipment in and out of operation and explain necessary actions and precautions to be taken regarding the overall plant monitoring and control system.

 NTS: DESIGN PROFESSIONAL SHALL INSERT AT NO. 1 REQUIRED DAYS.
 COORDINATE WITH SECTION 01821.

- B. Training covering the control equipment:
 - 1. The Supplier shall provide (--1--) days of operations training covering all system components.
 - 2. Training course shall accomplish the following:
 - a. Provide all instructions necessary to operate and utilize all system components.
 - b. Provide all instruction necessary to monitor and control the system processes from the designated control panel.
 - c. Explain procedures for control of the system during scheduled or rescheduled shutdown and the subsequent start-up.
 - d. Provide instructions for regular caretaking operations.

NTS: DESIGN PROFESSIONAL SHALL INSERT AT NO. 1 EITHER "PLC" OR
"SCADA SYSTEM".

C. (--1--) Training:

1. The SCADA System Supplier shall provide training that covers (--1--) as follows:
 - a. Provide an overview of system hardware and software.
 - b. It shall train people in configuration, operation and programming processors.
 - c. The emphasis shall be placed on how to perform set point changes, minor programming changes, range changes, diagnostics and upkeep of documentation.
 - d. Instruction for hardware and software maintenance, trouble shooting and maintenance planning.

NTS: DESIGN PROFESSIONAL SHALL EDIT SECTIONS "D" AND "E" BASED ON
THE PROJECT NEEDS.

D. Computer Hardware and Software:

1. Training prior to Operation Availability Demonstration (OAD):
 - a. Provide two days of operations training covering all system components prior to the start of the OAD.
 - b. Training course shall accomplish the following:
 - 1) Overview of systems functional capabilities.
 - 2) Equipment overview including system component functions, operating principals and proper use.
 - 3) Loading and start-up of the digital system hardware components.
 - 4) Use of system commands.
 - 5) Use of storage device for system backup.
 - 6) Description of the maintenance and troubleshooting aids of the system, including software diagnostic programs.
 - 7) Description of peripheral and other connected devices.
 - c. Personnel attending the training shall be capable of assuming the position of system operator during the OAD.

NTS: DESIGN PROFESSIONAL SHALL INSERT AT NO. 1 THE NUMBER OF DAYS.

E. SCADA System Maintenance Training Course:

1. Provide a (--1--) days, eight hours per day, course covering preventive and troubleshooting maintenance for the system components. The course shall familiarize the student with diagnostic capabilities of the system, both software

and hardware, and also the routine maintenance procedures on the system and the common peripheral devices.

2. As a minimum the course shall cover the following topics:
 - a. System overview description including the power subsystems and logic components of the processor bus.
 - b. Description of the maintenance and troubleshooting aids of the system including software diagnostic programs.
 - c. Description of all bus operations.
 - d. Description of peripheral and process interface devices.
 - e. Development of programs and control schemes.
 - f. Development and use of system displays.
 - g. Programming concepts and techniques.
 - h. Use of storage devices for system backup.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 13420

SCADA SYSTEM
PRIMARY SENSORS AND FIELD INSTRUMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish, install, calibrate, test, adjust and place into satisfactory operation all primary sensors and field instruments shown and specified herein.
2. Contract Documents illustrate and specify functional and general construction requirements of the sensors and field instruments and do not necessarily show or specify all components, wiring, electrical conduit, piping and accessories required to make a completely integrated system. CONTRACTOR shall provide all components, piping, wiring, electrical conduit, accessories and labor required for a complete, workable, and integrated system.
3. CONTRACTOR shall be responsible for installing in-line flow elements (magnetic flow meter flow tubes, insert flow tubes) and for providing taps in the process piping systems for installation of other flow, pressure, and temperature sensing instrumentation.

B. Coordination: Coordinate with other suppliers for installation of all items specified herein and required to ensure the complete and proper interfacing of all components and systems.

NTS: RETAIN ALL APPLICABLE SECTIONS BELOW. ADD OTHERS AS
REQUIRED. INSERT ALL APPLICABLE SECTIONS BELOW AT NO 1 - 2.

C. Related Sections:

1. Section 13401, SCADA System, General Requirements.
2. Section 13403, SCADA System, Startup and Field Testing.
3. Section 13404, SCADA System, Training.
4. Section (--1--), Exposed Piping Installation.
5. Section (--2--), Stainless Steel Pipe.

1.2 QUALITY ASSURANCE

- A. Comply with the requirements of Section 13401, SCADA System, General Requirements.
- B. Acceptable Manufacturers:
 - 1. Furnish primary sensors and field instruments by the named manufacturers or equal equipment by other manufacturers.
 - 2. The named manufacturers have been specified to establish the standard of quality and performance of the equipment to be supplied.
 - 3. Obtain all sensors and field instruments of a given type from the same manufacturer.
 - 4. The primary sensors and field devices shall be interchangeable with similar function existing primary sensors and field devices to minimize spare parts inventory.
- C. Manufacturers' Responsibilities and Services:
 - 1. Design and manufacture the primary sensors and field instruments in accordance with the applicable general design requirements specified in Section 13401, SCADA System, General Requirements, and the detailed Specifications herein.
 - 2. Field supervision, inspection, start-up and training in accordance with the requirements of Section 13403, SCADA System, Startup and Field Testing, and Section 13404, SCADA System, Training.

1.3 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 13401, SCADA System, General Requirements.
- B. Primary sensors and field instruments shall not be delivered to the Site until all product information and system Shop Drawings for the sensors and instruments have been approved by the ENGINEER and OWNER.

1.4 SUBMITTALS

- A. Comply with the requirements specified in Section 13401, SCADA System, General Requirements.

1.5 CHEMICAL SERVICE

NTS: RETAIN ALL APPLICABLE CHEMICALS. ADD OTHERS AS REQUIRED.
RETAIN OR EDIT THE PERCENT SOLUTIONS AND SPECIFIC GRAVITY.

- A. Where a primary element is designated for chemical service, all wetted components and appurtenances for that primary element shall be resistant to corrosion by that chemical. Chemicals referred to commonly as, "sodium hypochlorite" and "polymer" shall mean the following:
1. "SODIUM HYPOCHLORITE": Sodium Hypochlorite (NaOCl), 15 percent solution, Specific Gravity = 1.23.
 2. "POLYMER": Polymer Solution, 0.2 to 0.5 percent solution, Specific Gravity = 1.00.
 3. "FERRIC CHLORIDE": Ferric Chloride (FeCl₃), 43 percent solution, Specific Gravity = 1.46.
 4. "CAUSTIC": Sodium hydroxide (NaOH), 50 percent solution, Specific Gravity = 1.53.
 5. "HYDROCHLORIC ACID": Hydrochloric Acid (HCl), 38 percent solution, Specific Gravity = 1.4.
 6. "METHANOL": Methanol (CH₃OH), 99 percent solution, Specific Gravity = 0.792.
 7. "SODIUM BISULFITE": Sodium Bisulfite (NaHSO₃), 37 percent solution, Specific Gravity = 1.3

1.6 MATERIALS OF CONSTRUCTION FOR WETTABLE PARTS

 NTS: RETAIN ALL APPLICABLE PROCESS FLUIDS IN THE TABLE BELOW.
 ADD OTHERS AS REQUIRED.

- A. Provide the following materials of construction for primary sensors and field instrument (wetted) parts that come in contact with the following list of process fluids:

PROCESS FLUID	ELASTOMER	METAL	PLASTIC	OTHER
Air		Type 316 SS	PTFE (Teflon)	
Chemical Sump Drainage			PTFE (Teflon) Polypropylene	
Digester Gas	Viton	Alloy C276 Type 316 SS		
Ferric Chloride		Tantalum	PTFE (Teflon) Polypropylene	Ceramic
Glycerine Oil	Neoprene Viton	Type 316 SS	PTFE (Teflon) Polypropylene	

PROCESS FLUID	ELASTOMER	METAL	PLASTIC	OTHER
	Buna-N		PVC/CPVC	
Halocarbon	Neoprene	Type 316 SS	PTFE (Teflon)	
Hydrochloric Acid	Viton	Tantalum Zirconium Platinum	PTFE (Teflon)	Ceramic
Methanol		Type 316 SS	PTFE (Teflon)	
Non Potable Water	Neoprene	Type 316 SS	PTFE (Teflon)	Ceramic
Odor Control Scrubber Solution		Platinum	PTFE (Teflon)Tefzel	Ceramic
Raw Sewage	Viton	Type 316 SS	PTFE (Teflon) Polypropylene	
Sodium BiSulfite		Hastelloy B Zirconium Platinum	PTFE (Teflon) Polypropylene PVC/CPVC	Ceramic
Sodium Hydroxide		Hastelloy B Zirconium Platinum	PTFE (Teflon) Polypropylene PVC/CPVC	Ceramic
Sodium Hypochlorite		Hastelloy C Tantalum Titanium Platinum	PTFE (Teflon) PVC/CPVC Kynar	Ceramic
Silicone Oil	Viton Buna-N	Type 316 SS	PTFE (Teflon) Polypropylene	
Sludge	Neoprene Buna-N	Type 316 SS	PTFE (Teflon)	Ceramic

1.7 IDENTIFICATION TAGS

A. Performance Requirements:

1. Tag numbers of sensors and field instruments shall be as shown and as specified. For items not shown or specifically tagged, the item tag number shall be established by the System Supplier. All instruments, whether field or panel mounted, shall have an identification tag.

2. Information to be permanently engraved onto the tag shall include the identifying tag number, manufacturer, model number, service, and range.
3. The tags shall be fastened to the device with self-tapping stainless steel screws. Where fastening with screws cannot be accomplished the tags shall be permanently attached to the device by a circllet of stranded stainless steel wire rope and clamp.
4. All sensors and field instruments mounted on or within control panels and enclosures shall have the identification tag installed so that the engravings are easily visible to service personnel..

B. Construction Features:

1. Tags shall be engraved with 3/16-inch letters and constructed as follows.
 - a. 3/32-inch thick laminated phenolic for engraving composed of core, laminated on both sides with a matte (non-glare) finish cover sheet.
 - b. Core to be black; cover sheet to be white.
 - c. Mounting holes to be centered on width and 1/4-inch from each end.

1.8 FILLING LIQUID

- A. Use silicone oil except for process fluids containing chlorine. When the process fluid contains chlorine, the filling liquid shall be Halocarbon 63 or Flurolube 63.

 NTS: DESIGN PROFESSIONAL SHALL CONSULT WITH COUNTY REGARDING ALL THE MANUFACTURERS AND THE TERM "OR EQUAL" FOR EACH DEVICE.

PART 2 - PRODUCTS

- 2.1 PROCESS TAPS, SENSING LINES AND ACCESSORIES
- 2.2 LEVEL TRANSMITTER – ULTRASONIC TYPE
- 2.3 LEVEL TRANSMITTER – RADAR TYPE
- 2.4 LEVEL TRANSMITTER – HYDROSTATIC PRESSURE TYPE
- 2.5 LEVEL SWITCH – CONDUCTANCE TYPE
- 2.6 LEVEL SWITCH – FLOAT TYPE
- 2.7 FLOW – MAGNETIC FLOWTUBE AND TRANSMITTER
- 2.8 FLOW – ORIFICE PLATE
- 2.9 FLOW – VENTURI TUBE
- 2.10 FLOW – PARSHALL FLUME
- 2.11 FLOW – THERMAL MASS FLOWMETER
- 2.12 FLOW – DOPPLER FLOWMETER
- 2.13 FLOW – AREA VELOCITY FLOWMETER
- 2.14 FLOW – PROPELLER TYPE FLOWMETER
- 2.15 FLOW – ROTAMETER
- 2.16 FLOW SWITCH – THERMAL

- 2.17 FLOW SWITCH - MECHANICAL
- 2.18 PRESSURE TRANSMITTER (DIFFERENTIAL AND GAUGE)
- 2.19 PRESSURE GAUGE
- 2.20 PRESSURE SWITCH
- 2.21 DIAPHRAGM SEAL
- 2.22 TEMPERATURE SENSOR AND TRANSMITTER – RTD TYPE
- 2.23 TEMPERATURE SWITCH
- 2.24 THERMOMETER
- 2.25 DISSOLVED OXYGEN SENSOR AND TRANSMITTER
- 2.26 pH/ORP SENSOR AND TRANSMITTER
- 2.27 RESIDUAL CHLORINE ANALYZER AND TRANSMITTER
- 2.28 CHLORINE ANALYZER AND TRANSMITTER
- 2.29 SUSPENDED SOLIDS AND/OR TURBIDITY SENSOR AND TRANSMITTER
- 2.30 DENSITY MEASUREMENT SYSTEM
- 2.31 COMPOSITE SAMPLERS
- 2.32 LOWER EXPLOSION LIMIT (LEL) SENSOR AND TRANSMITTER
- 2.33 SULFITE SENSOR AND TRANSMITTER
- 2.34 NITRATE / NITRITE SENSOR AND TRANSMITTER
- 2.35 AMMONIA ANALYZER AND TRANSMITTER
- 2.36 PORTABLE MULTI-GAS MONITORS
- 2.37 INTRINSIC SAFETY DEVICES
- 2.38 SLUDGE BLANKET LEVEL MONITOR

 NTS: DESIGN PROFESSIONAL SHALL INSERT APPROPRIATE SPECIFICATIONS
 SECTIONS AT NO. 1 AND 2.

2.1 PROCESS TAPS, SENSING LINES AND ACCESSORIES

- A. Water Pressure Sensing Lines and Accessories for Flow and Pressure Transmitters:
 - 1. Material: Copper Water Tube, ASTM B-88, Type L, drawn temper or annealed.
 - 2. Pressure Rating: 150 psi.
 - 3. Size: 1/2-inch O.D. for water.
 - 4. Connections: Brass Compression Type, "Swagelok" by Crawford, or equal.
 - 5. Shut-off Valves:
 - a. Type: Ball.
 - b. Pressure Rating: 150 psi.
 - c. Body and Stem: Brass.
 - d. Ball: Stainless Steel
 - d. Packing: High Density TFE.
 - e. Handle: Steel.
 - f. Support Rings: TFE coated brass.
 - g. End Connections: Removable "Swagelok", or equal.

- h. Model: NIBCO, Apollo or equal.
 - 6. Manifolds:
 - a. Type: 5-valve and 3-valve meter manifolds.
 - b. Materials: Type 316 stainless steel body, bonnets and stems; delrin seats; teflon packing.
 - c. Products and Manufacturers: Provide one of the following:
 - 1) Anderson-Greenwood.
 - 2) Or equal.
- B. Air Pressure Sensing Lines and Accessories for Air Flow/Pressure Transmitters:
- 1. Material: Type 316 stainless steel tubing, ASTM A269, medium wall thickness.
 - 2. Pressure Rating: 150 psi.
 - 3. Size: 3/8-inch O.D. for air.
 - 4. Connections: Type 316 stainless steel compression type, "Swagelok" by Crawford, or equal.
 - 5. Shut-off Valves:
 - a. Type: Ball.
 - b. Pressure Rating: 150 psi.
 - c. Body, Ball and Stem: Type 316 stainless steel.
 - d. Packing: High density TFE.
 - e. Handle: Nylon with metal travel stops.
 - f. Support Rings: TFE coated Type 316 stainless steel.
 - g. End Connections: Removable "Swagelok", or equal.
 - h. Products and Manufacturers: Provide one of the following:
 - 1) 43 Series, as manufactured by Whitey.
 - 2) Or equal.
 - 6. Manifolds:
 - a. Type: 5-valve and 3-valve meter manifolds.
 - b. Materials: Type 316 stainless steel body, bonnets and stems; delrin seats; teflon packing.
 - c. Products and Manufacturers: Provide one of the following:
 - 1) Anderson-Greenwood.
 - 2) Or equal.
- C. Pressure Tap Sensing Lines and Accessories for Pressure Gauges and Pressure Switches:
- 1. For Process Sensing Taps in Ductile Iron, Steel and Stainless Steel Piping Systems:
 - a. Material and Fittings: Type 316 stainless steel pipe (ASTM A 312) and threaded fittings and adapters (ASTM A 403).
 - b. Sizes: 1/2-inch minimum for main sensing piping and 1/4-inch gauge and switch connections.
 - c. Pressure Rating: Equal to or greater than the applicable system test pressure as specified in the Exposed Piping Schedule in Section (--1--), Exposed Piping Installation.

- d. Accessories:
 - 1) For applications not requiring diaphragm seals, provide separate 1/2-inch Type 316 stainless steel threaded ball valve for each gauge and switch.
 - 2) For applications requiring diaphragm seals, provide a separate 1/2-inch threaded Type 316 stainless steel ball valve for seal process side shutoff.
- 2. For Process Sensing Taps in Copper and Thermoplastic Piping Systems:
 - a. Pipe Material and Fittings: Use same type of pipe material and fittings as that used in the process piping system. PVC pipe and fittings shall be provided in accordance with the requirements of Section (--2--), Thermoplastic Pipe.
 - b. Sizes: 1/2-inch minimum for main process sensing piping and 1/4-inch for gauge and switch connections.
 - c. Pressure Rating: Equal to or greater than the applicable system test pressure as specified in Section (--1--), Exposed Piping Installation.
 - d. Accessories:
 - 1) For copper piping system taps with or without seals, provide a separate 1/2-inch minimum threaded brass or bronze ball valve for each gauge and switch.
 - 2) For PVC piping systems with or without diaphragm seals, provide a separate 1/2-inch threaded ball valve for process sensing line shutoff.

2.2 LEVEL TRANSMITTER - ULTRASONIC TYPE

- A. Type: Microprocessor based, non-contacting, ultrasonic type continuous liquid level measuring system consisting of a transducer, remote transmitter, and interconnecting cable which produces an output signal linear with level.
- B. Performance Requirements:
 - 1. Accuracy: 0.25 percent of maximum range with temperature compensation.
 - 2. Resolution: 0.1 percent of range or 2 mm, whichever is greater.
 - 3. Range: As specified in the Instrument Index.
 - 4. Damping: Adjustable damping rate.
 - 5. Ambient Temperature:
 - a. Electronics: -5 degrees F to 122 degrees F.
 - b. Transducer: -40 degrees F to 200 degrees F.
 - 6. Output: Two isolated 4 to 20 mADC into 0 to 750 ohms.
 - 7. Relay Output: Six SPDT level alarm contacts rated 5A at 250 VAC, with LED indication of relay status.
 - 8. Power: 120 VAC, 60 Hz.
 - 9. Filter: Electronic filter to smooth the small variations in the level signal that result from surface waves or minor disturbances.
 - 10. Adjustable blanking distance.
 - 11. Provide flow conversion firmware for flow applications.

C. Construction Features:

1. Transmitter:
 - a. Microprocessor based control circuitry.
 - b. Handheld infrared wireless keypad for system programming and configuration. Programming and configuration values shall be stored in EEPROM memory that does not require battery back-up.
 - c. NEMA 4X polycarbonate enclosure. Provide Type 316 stainless steel hardware for mounting at the location shown on the Electrical Drawings.
 - d. Display: 100 mm x 40 mm multi-field backlit LCD.
 - e. Units of Measure: Feet/GPM, or as specified in the Instrument Index.
 - f. Front panel indication of loss of echo.
2. Transducer:
 - a. Kynar housing.
 - b. Integral temperature sensor for temperature compensation.
 - c. Piezoelectric barium titanite crystal.
 - d. Twelve degree beam angle for ranges less than 33 feet. Five degree beam angle for ranges greater than 33 feet.
 - e. Provide flange mounting or threaded pipe mounting as shown.
 - f. Provide coaxial communication cable from transducer to the remote transmitter; length as required.

D. Products and Manufacturers: Provide one of the following:

1. Model HydroRanger 200 with XPS-10 transducer as manufactured by Siemens, Milltronics.
2. Or equal.

NTS: ULTRASONIC IS THE REFERED TYPE. RADAR TECHNOLOGY WILL ONLY BE USED IN CONDITIONS WHERE THE ULTRASONIC LEVEL TRANSMITTER WILL NOT PROVIDE AN ACCURATE MEASUREMENT.

2.3 LEVEL TRANSMITTER – RADAR TYPE

A. Type: Non-contact.

B. Functions:

1. Antenna:
 - a. Radiate electromagnetic pulses from the transmitter towards the metered surface.
 - b. Receive the reflected signal.
2. Transmitter:
 - a. Generate and time the electrical pulses.
 - b. Count and convert the pulse travel times into an analog output signal linearly proportional to level.

- C. System Performance Requirements:
 1. Accuracy: Not less than ± 0.3 percent of full scale.
 2. Operating range of not less than 30 feet with deadband; minimum operating range of 12-inches.
 3. Transmitter Outputs: 4 to 20 mADC, direct acting and isolated, into 750 ohms.
 4. Ambient Temperature Range: -4 degrees F to 122 degrees F.
 5. Power Consumption: 15 watts maximum.

- D. Required Features:
 1. Antenna: Horn with extension, length as required.
 2. Transmitter:
 - a. Solid state construction.
 - b. Built-in digital filtering for EMI protection.
 - c. Handheld calibrator for field rangeability and recalibration.
 - d. Integral backlit LCD indicator scaled in engineering units.
 - e. Designed for operation on 120 VAC ± 15 percent, (60 Hz) or 24 VDC power supply.
 - f. Aluminum or Stainless Steel housing, NEMA 4/4X/IP66/IP67

 NTS: DESIGN PROFESSIONAL SHALL SELECT THE APPROPRIATE MODEL NUMBER AND INSERT AT NO. 1 BELOW.

- E. Product and Manufacturer: Provide the following:
 1. Model (--1--), as manufactured by Pulsar / Magnetrol.
 2. Or equal.

2.4 LEVEL TRANSMITTER – HYDROSTATIC PRESSURE TYPE

- A. Type: Measuring level by continuously measuring hydrostatic pressure via its sensing element, an ion implanted silicon semiconductor chip. Data is transmitted by an analog, 4 to 20 mADC output signal.
- B. Performance Requirements:
 1. Accuracy: ± 0.25 percent full scale.
 2. Zero Offset: ± 0.50 percent full scale.
 3. Span: ± 0.50 percent full scale.
 4. Temperature Ranges: -4 to 122 degrees F.
- C. Construction Features:
 1. Diaphragm: Type 316L stainless steel.
 2. Housing: Type 316 stainless steel.

3. Cable shall be provided of required length and fully submersible construction.
4. Power supply: 12 to 28 VDC with surge and lightning protection.
5. Electrical Connection: Attached 3-wire, 20 gauge polyethylene shielded unspliced cable.
6. Panel mounted meter shall be factory calibrated for required range, shall accept 4 to 20 mADC input, shall have a 3-1/2 digit vacuum fluorescent display in feet of water, shall be NEMA 4X rated and have two relay outputs for low level alarm.

 NTS: DESIGN PROFESSIONAL SHALL SELECT THE APPROPRIATE MODEL NUMBER AND INSERT AT NO. 1 BELOW.

- D. Manufacturers: Provide products of one of the following:
1. Model (--1--), as manufactured by GE / Druck.
 2. Or equal.

2.5 LEVEL SWITCH - CONDUCTANCE TYPE

- A. Type: Complete level sensing system utilizing conductance type measuring techniques to energize and de-energize independent control relays when the monitored medium reaches the corresponding level electrode elevation.

 NTS: DESIGN PROFESSIONAL SHALL INSERT THE REQUIRED INFORMATION AT NO. 1 AND 2.

- B. Performance Requirements:
1. Level Setpoints: (--1--).
 2. Total Number of Electrodes: (--2--).
- C. Construction Features:
1. Electrodes:
 - a. Type: Insulated, 1/4-inch diameter solid rod with bare end tip; cut to required length in field.
 - b. Insulation: PVC.
 - c. Rod Material: Type 316 stainless steel.
 2. Electrode Holders:
 - a. Type and Material: Flanged PVC; size as specified in Contract Documents.
 3. Control Relays:
 - a. Type: Solid state with low fixed sensitivity resistance of 10K ohms. Sensitivity shall be field changeable to adjust for process fluid

conductivity by means of external resistor replacement and relay shall be field convertible for direct or inverse operation.

- b. Power Supply: 120 VAC (-20, +10 percent), 60 Hz.
- c. Power Consumption: 9 volt-ampere, six watts.
- d. Sensing Circuit: Eight VAC and less than 30 ma short circuit.
- e. Contacts: Silver cadmium oxide.
- f. Load Contact Arrangement: Three separate and isolated sets of Form C (SPDT) contacts; one set wetted for local use, two sets dry for remote monitoring or external load control.
- g. Contact Ratings: Ten amps at 120 VAC, 240 VAC and 28 VDC.
- h. Temperature Range Limitations: -40 degrees F to 180 degrees F.
- i. Enclosure: NEMA 4X for field mounted locations; NEMA 1 for interior panel mounted installations.
- j. Quantity: One control relay per control or alarm electrode. Ground common electrode to each relay.

 NTS: DESIGN PROFESSIONAL SHALL SELECT THE APPROPRIATE MODEL NUMBERS AND INSERT AT NO. 1 AND NO. 2 BELOW.

- D. Product and Manufacturer: Provide one of the following:
 - 1. Model (--1--), as manufactured by Drexelbrook.
 - 2. Model (--2--), as manufactured by Warrick.
 - 3. Or equal.

2.6 LEVEL SWITCH - FLOAT TYPE

- A. General: The device shall be capable of detecting fluid level and initiating a signal.
- B. Type: Direct acting float.
- C. Required Features:
 - 1. Sealed SPDT control switch (non-mercury).
 - 2. Actuation by steel ball.
 - 3. High impact, corrosion resistant, polypropylene float material.
 - 4. Heavy duty, flexible 18 gauge, three connector, neoprene-jacketed cable with waterproof connection. Provide cable length, as required.
 - 5. Not sensitive to rotation.
 - 6. Operating Temperature: Up to 140 degrees F.
 - 7. Provide weighted stainless steel cable or mounting bracket to suit installation.

 NTS: DESIGN PROFESSIONAL SHALL SELECT THE APPROPRIATE MODEL NUMBERS AND INSERT AT NO. 1 AND 2 BELOW.

D. Product and Manufacturer: Provide the following:

1. Model (--1--), as manufactured by Warrick.
2. Model (--2--), as manufactured by Flygt.
3. Or equal.

2.7 FLOW - MAGNETIC FLOWTUBE AND TRANSMITTER

A. Functions:

1. Flowtube: Produce low level, high impedance pulsed DC signal proportional to the rate of fluid flow using the principle of electromagnetic induction.
2. Pulsed DC Magnetic Flow Transmitter: Drive the flowtube coils with pulsed DC power and convert the flowtube output signal into a DC current output linear to the flow rate.

B. System (Flowtube and Transmitter) Performance Requirements:

1. System Accuracy (with Analog Output): ±0.5 percent of flow rate or better over range from 1 fps to 31 fps.
2. System Repeatability: ±0.15 percent of flow rate or ±.0015 fps, whichever is greater.
3. Drift: Complete zero stability.
4. Minimum Fluid Conductivity Limit: Five microsiemens per centimeter or less.
5. Minimum Pre-amp Input Impedance: 10¹² ohms.
6. Fluid Property Effects: Accuracy unaffected by changes in fluid velocity, density, pressure, temperature or conductivity (above minimum conductivity limits).
7. Transmitter Outputs:
 - a. 4 to 20 mADC, direct acting and isolated, into 0 to 1000 ohms.
 - b. High accuracy, field adjustable scaled pulse output (0.1 to 10 Hz or greater) to drive local totalizer and provide scaled pulse output to Process Control System.
8. Power Consumption: Not to exceed 50 watts for flowtube and transmitter combined.
9. Operating Temperature: Suitable for operation with process fluid temperature from 0 degrees F to 140 degrees F.

NTS: DESIGN PROFESSIONAL SHALL INSERT THE CORRECT SPECIFICATION AT NO. 1.

10. Pressure Rating: Greater than or equal to test pressure specified in Section (--1--), Piping Systems, for appropriate piping system.

- C. Construction and Required Features:
1. Flowtube:
 - a. Type: Lined metal flowtubes.
 - b. Interchangeability: Ratio of flow velocity to voltage reference signals generated identical for all meter sizes to permit interchangeability with transmitter without requiring circuit modifications.
 - c. System accuracy in Paragraph 2.13.B.1. shall be proven by submittal of flow test curves of the actual meters being furnished.
 - d. Test curves shall show a minimum of ten equally spaced flow points. Tests shall be performed using water and a weight or volume tank. A "Master Meter" used, as a reference standard is not acceptable. The test setup shall be submitted and approved prior to testing.
 - e. Tube Material:
 - 1) Meter tubes 12-inch and smaller: Type 304 stainless steel.
 - 2) Metering tubes 14-inch and larger: Type 304 stainless steel, .125-inch wall thickness.
 - f. Electrodes:
 - 1) Concentric, conical or elliptical shaped.
 - 2) Material: Type 316 stainless steel or Hastelloy C based on fluid.
 - g. Lining: PFTE.
 - h. Enclosure:
 - 1) Materials and Rating: Cast low-copper aluminum alloy or fabricated sheet steel, NEMA 6 rated and capable of withstanding accidental submergence in 30 feet of water for 48 hours.
 - 2) Finish: Finish exterior, except for flange faces, with a high build epoxy paint.
 - i. End Connections: ANSI Class 150 suitable for mating with pipe specified.
 - j. Electrical Connections: 3/4-inch NPT tapped holes for power conduit fitting and signal conduit fittings.
 2. Pulsed DC Magnetic Flow Transmitter:
 - a. Solid state construction.
 - b. Pulse and analog outputs galvanically isolated from input and earth ground.
 - c. Automatic zeroing feature making it unnecessary to zero the instrument before or after placing it in operation.
 - d. Precalibrated span adjustment providing continuous span adjustment over entire range.
 - e. Range adjustment: Direct reading thumbwheel switches or calibrated potentiometer, continuously adjustable for full-scale settings from 1 to 31 feet per second.
 - f. Signal Conditioning: Adjustable damping circuit with response times of 1 to 25 seconds minimum.
 - g. Low Flow Cutoff: Provide automatic low flow cutoff circuitry to stop pulse output and local totalization when flow drops below 0.5 percent ± 0.2 percent of the calibrated upper range value.

- h. Enclosure:
 - 1) Die cast, low-copper aluminum alloy, NEMA 4.
 - 2) Finish: Epoxy coating.
- i. Mounting:
 - 1) All transmitter and driver electronics shall be remotely mounted from the flow tubes at locations shown on the Drawings.
 - 2) Provide complete Type 316 stainless steel mounting hardware.
 - 3) Type of mounting (wall, support frame or pipe stand), as required.
- j. Local Indication:
 - 1) 3-1/2 digit minimum LCD meter with field selectable engineering units; with linear 0 to 100 percent scale for flow rate indication. The engineering units shall be as specified in the Instrument List.
 - 2) 8 digit electronic LCD totalizer with reset and lithium battery backup. Count scaling shall be as specified in the Instrument List. Totalizer shall be integral with transmitter and visible through viewing window, or shall be externally mounted in a separate NEMA 4X enclosure or conduit with viewing window and installed adjacent to the transmitter.
- k. Power Requirements: Designed for operation on 120 VAC \pm ten percent, 60 Hz, \pm 3 Hz power supply.

 NTS: DESIGN PROFESSIONAL SHALL COORDINATE THE ACCESSORIES AS REQUIRED FOR THE PROJECT. DELETE ITEMS NOT REQUIRED.

- 3. Accessories:
 - a. Shielded cable assemblies of sufficient length for connection between flowtube and transmitter electronics.
 - b. Type 316 stainless steel grounding rings for flowtubes.
 - c. Type 316 stainless steel grounding straps.
 - d. Provide spool piece for replacement of each different size flow tube where no bypass piping is provided.
 - e. Provide one calibrator suitable to calibrate all pulsed DC magnetic flow transmitters provided.

 NTS: DESIGN PROFESSIONAL SHALL SELECT THE APPROPRIATE MODEL NUMBERS AND INSERT AT NO. 1 TO NO. 4 BELOW.

- D. Product and Manufacturer: Provide one of the following:
 - 1. Promag (--1--) Model magnetic flowtubes and Promag (--2--) model transmitters, as manufactured by Endress and Hauser.
 - 2. Series (--3--) flowmeter and Series (--4--) Signal Converter, as manufactured by ABB.

3. Or equal.

2.8 FLOW - ORIFICE PLATE

- A. General: Orifice plate shall be of the paddle type with orifice flanges.
- B. Required Features:
 1. Material: Type 316 stainless steel.
 2. Sharp edge concentric bore, the diameter of which has been calculated for a suitable pressure differential at a maximum flow rate.
 3. Sized as required for flow applications.
 4. Use orifice flanges or holding blocks for mounting.
 5. Upstream side of tab handle shall be indelibly marked "INLET", along with bore size, flange size and material.
 6. Provide complete calculations to ENGINEER prior to manufacture.
- C. Product and Manufacturer: Provide one of the following:
 1. Daniel Industries.
 2. Meriam Industries.
 3. Or equal.

2.9 FLOW - VENTURI TUBE

- A. General: The metering primary element shall be of the pressure differential producing type utilizing pure static pressure sensed at the inlet and throat sections.
- B. Required Features:
 1. Inlet section shall be comprised of a cylindrical section, of similar diameter as the pipe, in which the high-pressure tap is installed and shall incorporate to condition the flow profile before it enters the throat section.
 2. Laying length of the throat shall be at least 0.5 times the throat diameter. Low-pressure tap shall be installed in this section. Outlet cone shall be truncated, having an included angle of ten degrees. Interior and exterior surfaces, except the throat, shall be coated with a two-part bitumastic epoxy finish.
 3. Differential pressure shall indicate static pressure change only. Devices employing entire or partial Pitot effects, amplifying differential by changing flow direction at the point of sensing pressure, thus introducing unwanted hydraulic noise, shall not be acceptable.
 4. Tube coefficient shall be constant for pipe Reynolds number of about 50,000 and greater and independent of Beta ratio and line size.
 5. Tube shall be constructed of fabricated steel. Pressure connection for the inlet and throat section shall be Type 316 stainless steel. Throat liner shall be constructed of Type 316 stainless steel.
 6. Tube shall be provided with 150-pound flanges.

7. Metering element shall not have debris-collecting cavities or annular chambers and shall have a single pressure connection tap at the tube inlet and throat. In addition, a vent port and drain shall be included on a 90-degree plane to the metering tap on the inlet section.
8. Approval data shall state and substantiate the value and tolerance of the coefficient, the effect of up and downstream piping configurations, the head loss in percent of pipe velocity head and shall provide proof that the coefficient is independent of line size and Beta ratio.
9. Accuracy shall be ± 0.75 percent of actual rate of flow. The flow tube's design accuracy shall be substantiated by a two times standard deviation calculation of at least thirty tube coefficients of differing line size and Beta ratios that was performed by a secondary standard hydraulic laboratory whose calibration is directly traceable to NIST. CONTRACTOR can also submit a certificate of calibration for each supplied venturi flow tube from a hydraulic laboratory whose flow test fixture calibration is directly traceable to NIST..

C. Product and Manufacturer: Provide one of the following:

1. Primary Flow Signal.
2. Or equal.

 NTS: WHEN LOCAL READOUT IS REQUIRED, ADD THE FOLLOWING:

D. Local Indicator (Non-electrical):

1. Local indicator shall be suitable for either pipe stand or wall mounting.
2. Unit shall receive the differential pressure resulting from the passage of the process fluid through a flow meter and display said differential pressure directly as a flow.

E. Construction:

1. Encapsulated bourdon tube design.
2. Size: 6-inch.
3. Dial: White and black markings; 270 degree scale.
4. Body: NEMA 4X.
5. Working pressure: 1500 psig minimum.
6. Process Connections: Three-valve manifold with 1/2-inch process connections.
7. Accuracy: ± 1 percent of full scale.

 NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MODEL NUMBER AND INSERT AT NO. 1 BELOW.

- F. Product and Manufacturer: Provide one of the following:
 1. Model (--1--), as manufactured by Mid-West Instrument.
 2. Or equal.

2.10 FLOW - PARSHALL FLUME

- A. Furnish and install Parshall Flumes at each location shown on the Drawings.
- B. Features:
 1. Throat Size: As shown on the Drawings.
 2. Maximum Height of Flume Sidewalls above Crest: As shown on the Drawings.
 3. Field adjust the flume so the bottom and sides are plumb, level, straight and true and to drain dry upon zero flow.
 4. Material of Construction: Molded fiberglass reinforced polyester.
 - a. One piece construction, self-supporting, and shall not require any external supporting structure.
 - b. Wall Thickness: Ample with reinforcing ribs to prevent distortion during shipment, installation and operation.
 5. Interior Dimensions: Conform to U.S. Department of Interior, Bureau of Reclamation, Water Measurement Manual.
 6. Option Required: Staff gage graduated in inches with 48 divisions per foot attached to inside wall of flume.

 NTS: DESIGN PROFESSIONAL SHALL CONFIRM THAT THE FLUME IS INSTALLED TO MANUFACTURER’S RECOMMENDATIONS AND THAT THE FLUME APPROACH SHALL PROVIDE SMOOTH LAMINAR FLOW AT THE FLUME ENTRANCE.

- C. Product and Manufacturer: Provide one of the following:
 1. Engineered Fiberglass Composites, Inc.
 2. Or equal.

2.11 FLOW - THERMAL MASS FLOWMETER

- A. Thermal Mass Flow Sensors:
 1. Type: Thermal dispersion type linear flow meter that measures the differential temperature between two RTD's and produces an output signal linear to the mass flow rate of air.

NTS: CONFIRM ACTUAL REQUIREMENTS AND ACCURACY. INSERT
STRAIGHT LINE LENGTHS BASED ON MODEL AT NO. 1 AND 2. INSERT
OPERATING PRESSURE AT NO. 3.

B. Required Features:

1. Performance Requirements:

- a. Accuracy: \pm One percent of full scale for turndowns of ten to one or less and straight upstream/downstream piping runs of (--1--) diameters / (--2--
-) diameters.
- b. Repeatability: \pm 0.25 percent of full scale.
- c. Signal Output: 4 to 20 mADC, 500 ohms minimum load.
- d. Operating Pressure: (--3--).
- e. Response Time:
 - 1) Velocity: Five seconds or better.
 - 2) Temperature: Ten seconds or better.
- f. Flow Element Range: As specified in the table in Part 3 of this specification.
- g. Power Input: 115 VAC, \pm 15 VAC, 16 watts max.
- h. Operating Temperature:
 - 1) Flow Element: 35 degrees F to 220 degrees F.
 - 2) Electrical Housing: 0 degrees F to 150 degrees F.
- i. Calibration: Factory calibrated at specified flow range under given conditions.
- j. The transmitter shall be microprocessor based to permit field calibration to variable line sizes and minimum and maximum flow rates.
- k. Automatic sensor out-of-tolerance indication, alarm and re-averaging for multi-point flow elements.
- l. Transmitter shall have user access codes for security.
- m. Transmitter shall use lagrangian polynomial calibration data interpolation for maximum accuracy.

2. Construction Features:

- a. Process Connection: Flanged or compression fitting as shown on the Drawings.
- b. Insertion Length: Tip of probe to extend into process stream as recommended by product manufacturer. Pipe size will be as shown on the Drawings.
- c. Process Wetted Parts: Select a metal from the table in Article 1.6, above, based on process fluid being measured.
- d. Sensor Housing: Explosion proof Class 1, Group C and D, Division 1 and 2 if required. Explosion proof sensors shall have Explosion Proof FM approval.
- e. Remote Electronics Housing: NEMA 4X.
- f. Mounting:

- 1) Remote electronics housing shall be remotely mounted from the sensor housing at locations shown on the Drawings.
 - 2) Provide hot-tap type flow element mounting with isolation valve and packing gland for removal/reinsertion of element without shutting down the line. Materials shall be compatible with process piping material as specified in Division 15, Mechanical.
- g. Options and Accessories:
- 1) Local Indication:
 - a) Flow Rate Indicator: Liquid Crystal Display (LCD) with 3-1/2 digits scaled in SCFM.
 - b) Totalizer: Eight-digit Liquid Crystal Display (LCD) counter. Totalized flow and calibration data shall be stored in EEPROM circuitry indefinitely in case of power loss.
 - c) Flow Rate Indicator and Totalizer window shall be furnished with a hinged sunscreen as shown on the Drawings.
 - 2) Interconnecting Cable: Provide standard interconnecting cable between sensor head housing and remote electronic housing. Cable length shall be as shown on the Drawings.
 - 3) Provide special temperature compensation for process temperatures ± 30 degrees F.

 NTS: DESIGN PROFESSIONAL SHALL SELECT OR DELETE ITEM BELOW:.

- 4) Provide one portable calibrator unit for field checking and adjusting flow meter calibration.

 NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MODEL NUMBERS AND INSERT AT NO. 1 AND NO. 2 BELOW.

- C. Product and Manufacturer: Provide the following:
1. Model (--1--), as manufactured by Kurz.
 2. Model (--2--), as manufactured by STI Controls / Magnetrol.
 3. Or equal.

2.12 FLOW - DOPPLER FLOWMETER

- A. General:
1. All flowmeters shall be velocity profiling type utilizing ultrasonic Doppler velocity and ultrasonic level measurement techniques. The flowmeter shall utilize a combination velocity and level sensor to measure both the flow velocity profile and the depth. The sensor shall operate in stream

temperatures ranging from 23 degrees F to 95 degrees F and shall be temperature compensated. The probe shall be supplied with cable attached.

2. The flowmeter shall use ultrasonic pulse-Doppler technology with range gating to produce a velocity profile for velocity measurement. The system's ultrasonic sensor shall have four individual ultrasonic velocity measuring beams with nominal beam-widths of one degree. Each beam shall be capable of measuring an independent velocity profile. The velocity profile shall have a vertical resolution of 2 to 6-inches, user selectable. The flowmeter shall be capable of measuring velocity in a minimum depth of flow of 9-inches. Maximum velocity profiling range is dependent on solids concentrations:
 - a. 30-feet, nominal, in concentrations of 400 ppm (400 mg/l) and greater total suspended solids (TSS)
 - b. 20-feet, nominal, in concentrations of 50 ppm (50 mg/l) total suspended solids (TSS)
 - c. 9-feet, nominal, in water as clean as 2 ppm (2 mg/l) total suspended solids (TSS).
 - d. The meter shall have a velocity measurement range from 0 to 30 fps. Velocity accuracy shall be ± 1.0 percent of reading.
3. The flowmeter shall utilize an ultrasonic level sensor for level measurement. The level range shall be 0.4 to 20-feet with an accuracy of 0.5 percent of reading ± 0.20 -inches.
4. The flowmeter shall use the four velocity profiles and the measured level to calculate the flow rate value. This velocity profiling method shall provide a flow rate measurement accuracy of ± 2.0 percent of the reading or better over the entire range of measurement.
5. No in-situ calibration for velocity or level shall be required for commissioning the flowmeter. Periodic calibration of velocity or level measurement shall not be required to maintain the specified flow rate accuracy stated above.

B. Construction:

1. The flowmeter shall be powered from a 24 VDC plug-in power supply.
2. Each flowmeter shall consist of a control and analog module. Each module and associated components shall be housed in non-metallic enclosure with sealed front covers. The analog module shall have three independent analog output channels with printed circuit boards for outputting flow, level and velocity analog signals to the Plant Monitoring and Control System (PMCS) from which only the flow signal will be transmitted to the PMCS. Provide the following cables for wiring between the modules:
 - a. Communications cable for control and analog modules interfacing.
 - b. 24 VDC Power Wiring between the Control and Analog Modules: Type SJ 300V, 2/C#16 junior hard service cord.

C. Programming:

1. For flow rate measurement applications, the flowmeter shall be capable of computing flows in channels with circular, elliptical, rectangular and trapezoidal cross sections.
 2. The field selectable units of measurement shall be as follows:
 - a. Level: Inches, feet, centimeters and meters.
 - b. Velocity: Feet per second, centimeters per second and meters per second.
 - c. Flow Rate: Gallons per minute, million gallons per day, cubic feet per second, cubic centimeters per second and cubic meters per second.
- D. Program/Memory Storage:
1. Flowmeter programmed parameters shall be stored in a non-volatile memory to prevent loss in case of power interruption. An internal battery shall be provided for backup power to the internal clock and memory.
 2. The flowmeter shall have on-board data logging capability and be able to store at least 200,000 data points; equivalent to 140 days of data at 1-minute intervals. The data stored shall include level, average velocity, flow rate and temperature. Each data point shall include the date and time associated with the data.
 3. Flowmeter shall accept a 4 to 20mADC analog signal input from an optional external level sensing instrument. The flowmeters shall store data from this level sensor in addition to flow and level data from the flowmeter sensor.
 4. The flowmeter shall have an RS232 serial interface port for data retrieval with data transfer at 57,600 baud to any IBM compatible PC operating the manufacturer's data transfer software.
 5. The manufacturer's data transfer software shall be provided with the flowmeter. The software shall at a minimum operate on the Microsoft Windows '95 platform and be able to output data files that can be imported into Microsoft Excel or Access. The output data format shall be comma separated variable (.csv) ASCII strings. A ten foot interface cable for connecting the flowmeter to a PC shall also be provided.
- E. Installation and Startup
1. The flowmeter manufacturer shall provide instructions for the installation of the equipment supplied and shall make recommendations for the location of the flow sensor probe. Locations shall be selected for best flowmeter performance and to minimize the effect of sediment accumulation. The equipment manufacturer shall include two days of on-site installation planning and coordination for each installation by a factory-trained technician.
 2. The manufacturer shall provide a rectangular channel mounting, removable, frame for each sensor. Each frame will be inserted into guide slots in the channel walls. Frame shall be constructed from Type 316 stainless steel. Each frame shall be provided with corner braces so as to stiffen the frame and lifting eyes for removal of the frame from the channel. Frame shall

include a conduit to run the signal wire from the sensor to the transmitter. Frame shall extend 6-inches higher than the highest water surface elevation. Manufacturer shall coordinate with the CONTRACTOR for the exact dimensions of each frame.

3. The equipment manufacturer shall include three days of startup service for each installation by a factory-trained technician. The technician shall check installation for compliance with manufacturer's recommendations and recommend corrections to the OWNER, as required. The technician will program each flowmeter and data logger for the operational parameters for that location.

F. Product and Manufacturer: Provide the following:

1. ADFM Velocity Profiler Model Pro20, Teledyne ISCO/MGD Technologies Inc.
2. Or Equal.

2.13 FLOW – AREA VELOCITY FLOWMETER

A. Type: Uses Doppler technology with 500 kHz piezoelectric crystal transducers to measure the average velocity throughout the flow stream. An integral pressure transducer measures liquid level to determine the flow area and thereby calculate the flow rate.

B. Performance Requirements:

1. Accuracy: ± 0.1 ft/s for -5 to 5 ft/s and $\pm 2\%$ for 5 to 20 ft/s.
2. Temperature Range: 32 to 160 degrees F.
3. Flow Range: -5 to 20 ft/s.
4. Resolution: ± 0.024 ft/s
5. Data Storage: 230 Kbytes of data including level, velocity and flow rate.
6. Storage Intervals: 1, 2, 5, 10, 15, 30, 60 or 120 minutes.
7. Time base accuracy: ± 1 second per day.

C. Construction and Required Features:

1. Sensor materials: Polybutadiene based polyurethane, stainless steel.
2. Cable materials: PVC or CPVC.
3. Power: Two 6V Alkaline lantern batteries or One 12 V rechargeable Lead acid battery
4. Communication: Serial communication to an IBM PC or compatible computer with ISCO Flowlink Software Version 3.
5. Cable length: 25 ft with capability to extend to 50 ft.
6. Flow logger: Structural form molded polystyrene, NEMA 4X, 6 rated.

D. Product and Manufacturer: Provide the following:

1. Model 4150 as manufactured by ISCO.
2. Or Equal.

2.14 FLOW - PROPELLER TYPE FLOWMETER

- A. Type: Flanged tube type propeller meter with magnetic drive, electronic pulse transmitter and integral rate indicator and totalizer register.
- B. Performance Requirements:
 - 1. Accuracy: ± 2 percent of actual flow within specified range.
 - 2. Temperature Range: 120 degrees F maximum.
 - 3. Flow Overrange Capability: 25 percent above rated capacity for up to 15 percent of the total operating time of meter.
- C. Construction and Required Features:
 - 1. Meter shall be designed for 150 pounds working pressure rating.
 - 2. Flow tube shall be furnished with four straightening vanes radially spaced 90 degrees apart.
 - 3. Flow tube shall have the same nominal inside diameter throughout its length.
 - 4. Tube Materials:
 - a. Body and Straightening Vanes:
 - 1) Tube sizes from 4-inches through 12-inches: Fabricated steel, coated internally and externally with fusion bonded epoxy approved for use in potable water systems.
 - 2) Tube sizes from 14-inches through 36-inches: Fabricated steel with external and internal paint coating NSF approved for use in potable water systems.
 - b. Meter Head: Ductile Iron.
 - c. Propeller and Nut: Polypropylene.
 - d. Propeller Spindle: Ceramic-coated stainless steel.
 - e. Rotor Bearings: Ceramic.
 - f. Gear Housing: Factory Sealed, oil-filled, one-piece cast bronze.
 - g. Gears: Brass.
 - h. Shafts and Bolts: Stainless steel.
 - i. Magnets: Permanent, ceramic sleeve type.
 - 5. End Connections:
 - a. Tube sizes from 4-inches through 12-inches: AWWA Class D (125) Steel Flanges.
 - b. Tube sizes from 14-inches through 36-inches: ANSI Class 150 steel raised face flanges, suitable for mating with AWWA Class 125 ductile iron pipe flanges.
 - 6. Meterhead shall be connected to the tube body by means of a flanged connection.
 - 7. Flow tube shall be furnished with integral register, which shall consist of a rate indicator and totalizer.
 - 8. Rate indicator-totalizer shall have a 4-inch diameter indicator dial and a six digit, straight reading type totalizer.
 - 9. Totalizer shall have a test hand for checking the accuracy of the indicator.

10. Register unit shall be protected by an O-ring sealed register box complete with locking lid, and register drive shall be completely isolated from the water pressure by an O-ring sealed bronze housing.
11. Propeller shall be mounted on radial (sleeve type) ceramic bearings.
12. Propeller support shaft shall be fabricated of stainless steel.
13. Propeller shall be a molded polypropylene conical shaped, three bladed propeller.
14. Propeller shall be magnetically coupled to the register drive by the use of radial sleeve type ceramic magnets.
15. Meter shall be equipped with an integral electronic pulse transmitter installed between the meter head and direct reading register. Transmitter shall develop and transmit a high resolution pulse rate signal, proportional to flow rate, over a three wire cable to an external pulse rate frequency to DC current type flow rate receiver/transmitter.

 NTS: DESIGN PROFESSIONAL SHALL INSERT CORRECT SECTION NUMBER
 AT NO. 1 AND NO. 2 BELOW.

16. The electronic pulse rate transmitter and the external frequency to DC current flow transmitter shall comply with requirements specified in Paragraphs (--1--).D. and (--2--).E., below.

D. Electronic Pulse Rate Transmitter:

1. Input Power: 12 VDC, ± 5 percent, 50 ma maximum supplied by external frequency to DC current flow transmitter.
2. Output Signal:
 - a. Pulse Type: 112 VDC square wave.
 - b. Configuration: Open Collector.
 - c. Duty Cycle: 50/50 ± 20 percent.
 - d. Maximum Breakdown Voltage: 0 VDC/+15 VDC.
 - e. Maximum Load Current: 50 mADC.
 - f. Pulse Rate at Maximum Meter Indicator Scale Reading: 50 Hz.
3. Materials and Construction:
 - a. Housing: Aluminum with O-Ring Seals. Suitable for use in high humidity environment and capable of withstanding accidental submergence.
 - b. O-Ring Seals: Rubber.
 - c. Electrical Connections: Watertight and corrosion resistant fittings.
4. Interconnecting Cable:
 - a. Type: Three conductor, stranded No. 18 AWG, shielded; Belden 8770 or equal.
 - b. Length: Provide sufficient length of cable to extend from meter to nearby external flow transmitter (ten feet minimum).

- E. Frequency to DC Current Flow Transmitter:
1. General: Provide external frequency to DC current transmitter of quartz crystal time-base design for providing power to and receiving pulse signal from the propeller meter pulse transmitter, and transmitting a 4 to 20 mADC output signal proportional to flow rate to the Process Control System. Coordinate to ensure compatibility of external flow transmitter and meter pulse rate transmitter.
 2. Performance Specifications:
 - a. Ambient Temperature Range: 0 degrees F to 165 degrees F.
 - b. Ambient Temperature Effect: ± 0.005 percent per degree F over maximum operating temperature range.
 - c. Isolation: Transformer isolated output and power input with common mode rejection exceeding 120 dB at 60 Hz with a limit of 500 volts rms.
 - d. Interference Rejection: Provide filters for RFI/EMI protection.
 3. Input:
 - a. Type: Three wire, Floating Transformer coupled with 12-volt excitation provided for propeller meter magnetic pickup and pre-amp.
 - b. Impedance: Greater than 5K ohms.
 - c. Amplitude: 300 mV P/P to 20 volt P/P; provide input attenuation for higher input voltages as necessary.
 - d. Span: Jumper selectable ranges from 0 to 1.56 through 50 Hz.
 4. Output:
 - a. Type: Operational amplifier feedback current source, with output limited to 150 percent of maximum output range value.
 - b. Current Range: 4 to 20 mADC into 0 to 1200 ohm load at 24 VDC.
 - c. Load Effect: ± 0.01 percent of span from 0 to maximum load resistance.
 5. Front Panel Adjustments by means of multiple potentiometers:
 - a. Span: Fully adjustable over pre-selected input range to 100 percent of selected output span.
 - b. Zero: At minimum input, adjustable to ± 10 percent of selected output span.
 6. Power Input: Designated to operate on 120 VAC, 60 Hz ± 10 percent power with five watts nominal power consumption.
 7. Housing: General purpose housing with angle bracket mounting for installation in larger, NEMA 4X rated field mounted enclosure.
 8. Electrical Connections: Screw-type barrier terminal strips on front of transmitter housing.
 9. Enclosure: Provide NEMA 4X rated enclosure for field mounting the flow transmitter near the propeller meter. Enclosure shall be suitable for support frame or pipe stand mounting. Provide stainless steel mounting hardware, brackets and fasteners.

 NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MODEL
 NUMBER AND INSERT AT NO. 1 BELOW.

- F. Product and Manufacturer: Provide the following:
 - 1. Propeller Meter and Pulse Rate Transmitter:
 - a. Model (--1--), as manufactured by Water Specialties / McCrometer.
 - b. Or Equal.

 NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MODEL NUMBER AND INSERT AT NO. 1.

- 2. Flow Transmitters:
 - a. Model (--1--) Frequency to DC Transmitter, as manufactured by Moore Industries.
 - b. Or equal.

2.15 FLOW - ROTAMETER

 NTS: INSERT THE CORRECT FLOAT TYPE, FRAME AND TUBE CONSTRUCTION MATERIAL, END FITTINGS AT NO. 1, 2, 3 & 4.

- A. Type: High Flow Variable-area Flowmeter:
 - 1. Accuracy: ± Five percent of maximum flow.
 - 2. Range: 10 to 1.
 - 3. Float: (--1--).
 - 4. Frame: (--2--).
 - 5. Tube: (--3--).
 - 6. End Fittings: (--4--).
 - 7. Service: Liquid or gas flows.

 NTS: DESIGN PROFESSIONAL SHALL INSERT CORRECT MODEL NUMBER AT NO. 1.

- B. Product and Manufacturer: Provide one of the following:
 - 1. Model (--1--), as manufactured by Blue-White.
 - 2. Or equal.

2.16 FLOW SWITCH – THERMAL

- A. The flow switch shall detect the flow speed using the calorimetric measuring principle and shall provide an output based on the flow setting.

1. Accuracy (includes combined effects of linearity, hysteresis and repeatability): ± 0.10 percent of calibrated span.
2. Repeatability: 0.05 percent of calibrated span.
3. Hysteresis: 0.05 percent of calibrated span.
4. Stability (drift over a six month period): Not more than ± 0.25 percent of transmitters upper range limit.
5. Ambient Temperature Effect: Total Error per 100 degrees F change between the limits of -20 degrees F and +180 degrees F: Not more than ± 1.0 percent of the transmitters upper range limit (maximum span).
6. Supply Voltage Effect: Output change not greater than 0.005 percent of span for each one-volt change in supply voltage.
7. Output:
 - a. Isolated direct acting 4 to 20 mA DC.
 - b. Digital process variable signal superimposed on 4 to 20 mA DC signal without compromising loop integrity.
8. Solid state electronic components.
9. Positive overrange protection of at least 1.25 times the maximum span limit.
10. Calibration Adjustments:
 - a. Zero: Adjustable in electronics compartment.
 - b. Span: Course and fine span adjustments in electronics compartment.
11. Zero elevation and suppression capability to the extent that the amount of suppression plus calibrated span does not exceed the upper range limits of the sensor.
12. Adjustable internal damping.
13. Measuring elements protected by sealing diaphragm.
14. Built-in electrical surge and RFI protection.
15. Valves:
 - a. For gauge pressure measurement: in all cases, except for interlock safety, provide a single shutoff valve at the process line tap to enable live process removal of the transmitter. Comply with requirements of Article 2.1, above.
 - b. For differential pressure measurement: provide a three-way valve manifold constructed of 316 stainless steel on the differential pressure transmitter for pressure equalization and shutoff. Comply with requirements of Article 2.1, above.
16. Integral square root extraction providing linear 4 to 20 mA DC output proportional to flow when required.
17. Electric Conduit Connection: 1/2-inch NPT.
18. Process Connections: 1/2-inch NPT.
19. The transmitter shall be loop powered from an external DC voltage source (24 VDC nominal).
20. Type 316 stainless steel mounting bracket and hardware suitable for mounting transmitter on flat vertical surface or 2-inch diameter pipe.
21. Process Wetted Parts: Type 316 stainless steel.
22. Non-Wetted Parts:
 - a. Body and Process Connection Bolting: Type 316 stainless steel.

- b. Housing and Cover: Die cast low copper aluminum alloy finished with epoxy paint system; covers shall be threaded and seated on Buna-N O-rings; NEMA 4 rating.
- c. Capsule Fill Liquid: Silicone oil.
- 23. Indicator: Provide integral indicator in engineering units.
- 24. Hazardous Area Requirements: Where so required, provide transmitters rated for use in Class I, Group D, Division 1 hazardous areas.
- 25. Hand held interface with keyboard and LED display capable of easily configuring and testing the transmitter.

 NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MODEL NUMBERS AND INSERT AT NO. 1 AND NO. 2 BELOW.

- C. Product and Manufacturers: Provide one of the following:
 - 1. Model (--1--), as manufactured by Foxboro.
 - 2. Model (--2--), as manufactured by Rosemount, Incorporated.
 - 3. Or equal.

2.19 PRESSURE GAUGE

- A. Bourdon Tube Pressure Element Type, Liquid Filled Gage (for pressure ranges of 15 psi and greater and vacuum ranges to 30-inches Hg):
 - 1. Performance Requirements:
 - a. Accuracy: ± 0.5 percent of span (ANSI B40.1 Grade 2A).
 - 2. Construction Features:
 - a. Case:
 - 1) Solid front design constructed of glass filled polyester.
 - 2) Color: Black.
 - b. Ring: Threaded, glass filled polyester.
 - c. Full blowout back.
 - d. Window: Glass.
 - e. Dial: White with black marking; 270-degree scale.
 - f. Bourdon Tube and Socket: Type 316 Stainless Steel, heliarc welded, unless otherwise specified in the Instrument Index.
 - g. Movement: Cam and roller movement, 300 Series stainless steel.
 - h. Size: 4-1/2-inch.
 - i. Connection: 1/4-inch male NPT back or bottom, as required.
 - j. Mounting: Stem, flush panel or wall mounting, as required.
 - k. Adjustable pointer.
 - l. Externally accessible zero adjustment.
 - m. Built-in overload and underload movement stops.

NTS: DESIGN PROFESSIONAL SHALL USE A PRESSURE SNUBBER BASED ON APPLICATION.

- n. Pressure Snubber: Sintered Type 316 stainless steel snubber threaded into gage socket or in external stainless steel housing with 1/4-inch NPT male and female connections.
- o. Filling Liquid: All applications, except Chlorine and Fluoride Systems: Flurolube Oil.
- p. Process Isolation: Provide gage cocks or ball valves for process isolation in accordance with the requirements of Article 2.1, above.

NTS: DESIGN PROFESSIONAL SHALL RETAIN FEATURE IN PARAGRAPH "q" BELOW AS REQUIRED FOR ALL MEDIUMS, EXCEPT AIR OR POTABLE WATER.

- q. Provide diaphragm seal.

NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MODEL NUMBERS AND INSERT AT NO. 1 AND NO. 2 BELOW.

- 3. Product and Manufacturer: Provide one of the following:
 - a. (--1--), as manufactured by US Gauge.
 - b. (--2--), as manufactured by Ashcroft.
 - c. Or equal.

2.20 PRESSURE SWITCH

- A. Type: Switch assembly with diaphragm piston actuator for sensing gauge or differential pressure.

NTS: DESIGN PROFESSIONAL SHALL INSERT THE REQUIRED INFORMATION AT NO. 1 TO NO. 3.

- B. Performance Specifications:
 - 1. Adjustable Operating Range: (--1--).
 - 2. Setpoint Accuracy: \pm One percent of span.
 - 3. Actuating Setpoint: (--2--).
 - 4. Adjustable Deadband Range and Setting:

- a. Maximum full scale, minimum seven percent of full scale.
- b. Required Deadband Setting: (--3--).

 NTS: CHOOSE OPTIONS AND EDIT ACCORDINGLY.

- 5. Switch: Snap action, SPDT rated not less than five amp resistive at 120 VAC and 1/2 amp resistive at 125 VDC. Provide DPDT contacts and other optional switch configurations when so required.
- 6. Switch and Reset (Deadband) Action: Adjustable, Fixed, Manual Reset or Two Stage type.

C. Construction Features:

- 1. Pressure Transducer Housing and Diaphragm Materials:
 - a. Air Service: Type 303 stainless steel with Viton diaphragm.
 - b. Other Services: Aluminum with Buna-N Diaphragm.
- 2. Set and Reset Point Adjustments: Adjustable external adjusting nuts and pressure setting scales.
- 3. Process Connection: 1/4-inch NPT.
- 4. Housing: Copper-free die cast aluminum, NEMA 4; NEMA 7 construction required for hazardous areas.
- 5. External Mounting Lugs.
- 6. Adjusting Nuts Metal Cover with Gasket on NEMA 4 and NEMA 7 rated units.
- 7. Electrical Connection: 3/4-inch NPT.

 NTS: DESIGN PROFESSIONAL SHALL RETAIN FEATURE IN PARAGRAPH "8" BELOW AS REQUIRED FOR ALL MEDIUMS, EXCEPT AIR OR POTABLE WATER.

- 8. Provide diaphragm seal.

 NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MODEL NUMBERS AND INSERT AT NO. 1 TO NO. 2 BELOW.

D. Product Manufacturer: Provide pressure switch of one of the following:

- 1. Model (--1--), as manufactured by Ashcroft.
- 2. Model (--2--), as manufactured by United Electric Controls.
- 3. Or equal.

2.21 DIAPHRAGM SEAL

A. General: Furnish diaphragm seals for pressure gages, pressure transmitters and pressure switches at locations shown on the Drawings and as specified.

B. Required Features:

1. Provide fill/bleed screw to permit filling of instrument and diaphragm seal.
2. Instrument Connection: 1/4-inch NPT.
3. Process Connection: 1/2-inch NPT.
4. Working Pressure Rating: Equal to or greater than the attached gage or switch operating pressure specified in Section 15050, Piping Systems, whichever is greater.
5. Bolting Materials: Type 316 stainless steel.
6. 1/4-inch NPT flushing connection.
7. Filling Fluid: Silicone oil.

 NTS: DESIGN PROFESSIONAL SHALL RETAIN FEATURES IN PARAGRAPH "8"
 IF PROCESS FLUID IS DIFFICULT TO FLUSH.

8. Provide a clean-out ring which holds the diaphragm captive in the upper housing to allow the upper housing assembly to be removed for recalibration or cleaning of the process side housing without the loss of filling liquid or change in calibration.

C. Construction Features:

1. Top Housing: Type 316 stainless steel.

 NTS: DESIGN PROFESSIONAL SHALL RETAIN ALL FEATURES IN
 PARAGRAPH "2" BELOW AS REQUIRED. DELETE OTHERS NOT REQUIRED.

2. Diaphragms, O-rings and Gaskets:

<u>Process Fluid</u>	<u>Diaphragm</u>	<u>O-Ring</u>	<u>Gasket</u>
Sludge	Type 316 SS	Buna-N	Buna-S
Polymer	Type 316 SS	Buna-N	Buna-S
Alum	Type 316 SS	Buna-N	Buna-S
Chlorine Gas	Teflon	Teflon	Teflon
Chlorine Solution	Teflon	Teflon	Teflon
Sodium Chloride	Teflon	Teflon	Teflon
Ammonia	Type 316 SS	Teflon	Teflon
Carbon	Type 316 SS	Buna-N	Buna-N

<u>Process Fluid</u>	<u>Diaphragm</u>	<u>O-Ring</u>	<u>Gasket</u>
Fluoride	Hastelloy C	Viton	Viton
Lime	Type 316 SS	Teflon	Teflon
Potassium Permanganate	Carpenter 20	Viton	Viton
Sodium Hypochlorite	Teflon	Teflon	Teflon
Sodium Hydroxide	Teflon	Teflon	Teflon
Sodium BiSulfite	Teflon	Teflon	Teflon

3. Process Side Housing Material: Type 316 stainless steel for metallic piping; CPVC to match non-metallic piping.

D. Assembly and Calibration:

1. The complete diaphragm seal assembly, including gage, switch or transmitter, shall be factory assembled, filled and calibrated to the ranges and switch set points specified prior to shipment.
2. System Supplier shall be responsible for assuring that fill volumes and sensitivities of the supplied seals and diaphragms are suitable to provide the required gage, switch or transmitter accuracy over the specified measurement range or at switch set points.
3. Location and orientation of the gages, switches and seal assemblies shall be coordinated with the actual piping and equipment installations so that gages and indicators shall be easily read and accessed for maintenance by plant personnel.
4. Where field mounting and orientation conflicts arise due to incomplete coordination with field changes in the process piping and equipment installation, assemblies shall be relocated, re-oriented, re-assembled and re-calibrated as directed by ENGINEER.

 NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MODEL NUMBER AND INSERT AT NO. 1 BELOW.

E. Product and Manufacturer: Provide one of the following:

1. Type (--1--), as manufactured by Ashcroft.
2. Or equal.

2.22 TEMPERATURE SENSOR AND TRANSMITTER - RTD TYPE

A. Sensor Requirements:

1. Accuracy: Plus or minus 0.5 degrees F or plus or minus 0.5 percent of actual temperature, whichever is greater from 32 degrees F to 1200 degrees F.
2. Stability: Less than ± 0.1 degrees F shift from initial calibration in one year.
3. Resistance: 100 ohms at 32 degrees F.
4. Resistance Change: 0.0021 ohms per degree Fahrenheit.

5. Sensor Assembly:
 - a. Platinum RTD type sensor assembly consisting of the following components:
 - 1) Three lead wire type RTD with primary resistance wire wound in a coil.
 - 2) No. 22 AWG minimum insulated leads and resistance wire enclosed in small diameter seamless, closed end sheath.
 - 3) Sheath surrounded by a thermowell designed for threaded, flanged or welded process mounting as required.
 - 4) Element, sheath and thermowell joined to an industrial, heavy-duty, waterproof type head using extension fittings; compression springs and pressure plate to maintain RTD tip contact with end of thermowell. Sheath, thermowell and extension fittings shall be Type 316 stainless steel.
 - b. Insertion Length: Coordinate lengths with process piping and installation requirements.
 - c. Three lead extension wire between connection head and transmitter of either shielded, armored or waterproof type as recommended by the manufacturer.
 - d. RTD assembly shall be of the spring-loaded design. NEMA 4X connection head shall be furnished with threaded cover and O-ring gasket.

B. Transmitter Requirements:

1. Accuracy: Plus or minus 0.2 percent of calibrated span, including repeatability, hysteresis, linearity and adjustment resolution. (Not including sensor error).
2. Output: 4 to 20 mA DC linear with temperature. Digital process variable signal superimposed on 4 to 20 mA DC signal without compromising loop integrity.
3. Ambient Temperature Limits: -40 degrees F to 185 degrees F.
4. Ambient Temperature Effect: Not more than plus or minus 0.03 percent of reading. Change in calibrated span for a 50 degrees F change in ambient temperature within operative limits.
5. Power Supply Effect: Maximum of plus or minus 0.005 percent of span per one volt change in power supply.
6. Solid-state electronics.
7. Input/output isolation.
8. Factory calibrated for the operating temperature ranges required.
9. Field adjustable span and zero settings.
10. Built-in EMI and RFI protection.
11. Electronics housing designed and constructed to meet NEMA 4X requirements and equipped with brackets suitable for pipe stand mounting remote from the RTD Sensor assembly.
12. Barrier terminal strip wiring connections.
13. 3/4-inch internal NPT conduit connections.
14. Designed to operate from remote power supply at 12 to 45 VDC.

- C. Accessories: Provide a local loop powered 0 to 100 percent analog or 3-1/2 digit LCD indicator mounted either in the transmitter enclosure and visible through an inspection window, or mounted in a separate enclosure installed near the transmitter. LCD indicator shall be calibrated in engineering units and shall have an accuracy of plus or minus 0.1 percent of span and plus or minus one count. Analog meter shall have an accuracy of \pm two percent and shall be furnished with an auxiliary stainless steel tag to indicate 0 to 100 percent calibrated range in engineering units.

 NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MODEL
 NUMBERS AND INSERT AT NO. 1 AND 2 BELOW.

- D. Product and Manufacturer: Provide one of the following:
 - 1. Sensors and Transmitters:
 - a. Model (--1--), as manufactured by Ashcroft.
 - b. Model (--2--), as manufactured by Rosemount, Incorporated.
 - c. Or equal.

2.23 TEMPERATURE SWITCH

- A. Type: Vapor pressure sensing with liquid filled bulb attached to bellows or diaphragm pressure element.
- B. Function: Open or close one or more sets of contacts when the sensed temperature increases or decreases to the switch set point.
- C. Performance Specifications:
 - 1. Setpoint Accuracy and Repeatability: \pm One percent of adjustable range span.
 - 2. Setpoint Shift: Less than one percent of range span for 50 degrees F change in ambient temperature.
 - 3. Deadband: Minimum of one percent of adjustable range span.
 - 4. Contacts: Snap action, SPDT rated not less than five amps at 120 VAC.
 - 5. Environmental Conditions: Suitable for use under the environmental conditions specified in Section 13401, Process Control System General Requirements for Process Instrumentation.
- D. Required Features:
 - 1. Remote mounted bulb and capillary or local mounted bulb, as required.
 - 2. Field adjustable set point(s) over full span of the adjustable range by means of external tamper proof calibrated dials.
 - 3. Contacts wired N.O. or N.C., as required.
 - 4. Screw type terminals.

5. Type 316 stainless steel thermo well with 1/2-inch NPT process connection for both remote and local mounted bulbs.
6. 3/4-inch internal NPT electrical connections.

 NTS: CHOOSE OPTIONS SPECIFIED IN PARAGRAPHS "7", "8", "9" OR "10"
 BELOW.

7. NEMA 4, 6, 7, or 9 enclosure, as required.
8. Enclosure suitable for wall or pipe stand mounting.
9. Capillary of sufficient length to extend from process connection to switch for remote mounted bulbs.
10. Field adjustable on-off differential (deadband) from above specified minimum value to maximum of the full range.

 NTS: DESIGN PROFESSIONAL SHALL SELECT ALL REQUIRED MATERIAL IN
 PARAGRAPH "E" BELOW.

E. Materials:

1. Bulb, Capillary, Bellows and Disc Spring Pressure Elements: Type 304 or 316 stainless steel.
2. Diaphragm Elements: Teflon.
3. Enclosure: Die cast aluminum.

 NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MODEL
 NUMBER AND INSERT AT NO. 1 BELOW.

F. Product and Manufacturer: Provide one of the following:

1. Model (--1--), as manufactured by Barksdale Controls.
2. Or equal.

2.24 THERMOMETER

A. Required Features:

1. Type: Bi-metal.
2. Case Material: Type 304 stainless steel.
3. Dial Size: Five-inch, black numerals and pointer, white background.
4. Form: Adjustable "universal" swivel head.
5. Accuracy: ± One percent of full scale.
6. Thermowell:

- a. Material: Type 316 stainless steel or as required to be compatible with the process fluid as indicated in the Instrument Index.
- b. Construction: Drilled bar stock.
- c. Thread Size: Male 1-inch NPT.
- d. Lag Extension: Three-inch.

 NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MODEL NUMBER AND INSERT AT NO. 1 BELOW.

- B. Products and Manufacturers: Provide one of the following:
 - 1. Model (--1--), as manufactured by Ashcroft.
 - 2. Or equal.

2.25 DISSOLVED OXYGEN SENSOR AND TRANSMITTER

- A. General: Continuous dissolved oxygen monitoring system in wastewater using dissolved oxygen probe, sensor and transmitter. Method of operation shall use luminescence technology.
- B. Required Features:
 - 1. Transmitter:
 - a. Range Capability: 0 to 20 mg/l (PPM) or 0 to 999.9 percent saturation dissolved oxygen.
 - b. Accuracy: ± 0.1 percent of span.
 - c. Repeatability: ± 0.05 percent of span.
 - d. Temperature Drift: Zero and Span: ± 0.02 percent of span per degree C.
 - e. Automatic Temperature Compensation for specified range.
 - f. Response Time: 1-60 seconds to 90 percent of value on step change.
 - g. Outputs: Two isolated 4 to 20 mADC. Three Form C contacts rated five amp, 24VDC/230VAC..
 - h. Alarm Outputs: Lo, Lo-deadband, Hi, Hi-deadband, off delay, on delay.
 - i. Display: LED backlit graphic dot matrix LCD with 128 x 64 pixels.
 - j. Ambient Conditions:
 - 1) Operating temperature: -4 degrees F to 140 degrees F
 - 2) Relative humidity: 0 to 95 percent, non condensing
 - k. Power Requirements: 120 VAC, 60 Hz.

 NTS: DESIGN PROFESSIONAL TO DETERMINE HOW THE TRANSMITTER SHOULD BE INSTALLED. THE TRANSMITTER IS ABLE TO BE PANEL MOUNTED, OR MOUNTED AS A STANDALONE UNIT EITHER ON A BACK PANEL OR PIPE STAND.

1. Enclosure Construction:
 - 1) NEMA 4X rating.
 - 2) Four ½-inch conduit holes.
 - 3) Stainless steel hardware.
 - 4) Transmitter shall be panel mounted and/or stand alone. (--1--)
 - 5) Mounting transmitter on handrails is not allowed.
- m. Automatic Wash Cycle:
 - 1) Programmable output to activate air cleaning system.
 - 2) Transmitter shall hold last measured value during wash cycle.
2. Probe / Sensor:
 - a. Range Capability: 0.01 to 20 mg/l (PPM) or 0 to 200 percent saturation dissolved oxygen.
 - b. Resolution: 0.01 ppm
 - c. Repeatability: ±0.05 ppm
 - d. Accuracy:
 - 1) Less than 1 ppm: ±0.1 ppm
 - 2) Greater than 1 ppm: ±0.2 ppm
 - e. Temperature Range: 32 degrees F to 122 degrees F
 - f. Automatic temperature compensation
 - g. Sensor interface: Modbus
 - h. Material:
 - 1) Sensor: Polybutyl Methacrolate
 - 2) Probe: Foamed Noryl and 316 SS

 NTS: DESIGN PROFESSIONAL SHALL COORDINATE THE PROBE MOUNTING
 DETAILS AT NO. 1. DESIGN PROFESSIONAL SHALL COORDINATE CABLE
 LENGTH AT NO. 2.

- i. Probe Mounting: (--1--)
 1. The dissolved oxygen probe shall be supplied with cable of sufficient length to connect to the transmitter. (--2--)
 2. Mounting bracket shall be provided for attaching the probe to a pipe stand. Mounting on handrails is not allowed.
 3. All probe mounting hardware shall be of corrosion resistant construction.
 4. Probe mounting system shall be adjustable to allow flexibility of probe depth under water.
- j. Calibration:
 1. Air Calibration:
 2. Zero Sample Calibration
 3. Transmitter shall transmit and hold last measured value prior to initiation of a cleaning cycle and for a programmable period after cleaning cycle completion.
3. Air Blast Head Assemblies:

- a. Air blast system shall reduce biogrowth and other types of fouling on the sensor.
- b. Dissolved Oxygen system supplier shall furnish all assemblies, air tubing and components to provide adequate air blast cleaning to the probe and sensor from the air system.

 NTS: AT NO.1, CONSULT WITH THE CLIENT TO DETERMINE IF THE EXISTING PLANT AIR SYSTEM CAN BE USED. IF PLANT AIR IS TO BE USED, SECTION FOR AIR BLAST COMPRESSOR SHOULD BE DELETED. DESIGN PROFESSIONAL TO COORDINATE DESIGN DETAILS TO TIE INTO EXISTING PLANT AIR SYSTEM. IF PLANT AIR SYSTEM IS NOT USED, ENGINEER TO COORDINATE AIR BLAST COMPRESSOR LOCATION AND INSTALLATION DETAILS. AT NO. 2, DESIGN PROFESSIONAL SHALL CONSULT WITH THE CLIENT TO DETERMINE HOW THE COMPRESSOR SHOULD BE INSTALLED. THE COMPRESSOR IS ABLE TO BE MOUNTED ON WALL OR ON A PIPE STAND.

- 4. Air Blast Compressor (--1--)
 - a. Ambient Conditions:
 - 1. Operating temperature: -32 degrees F to 104 degrees F
 - 2. Relative humidity: 0 to 95 percent, non condensing
 - b. Enclosure Construction:
 - 1. NEMA 4X rating.
 - 2. Four ½-inch conduit holes.
 - 3. Stainless steel hardware.
 - 4. Compressor system shall be panel mounted and/or stand alone. (--2--)
 - c. Power Requirements:
 - 1. 120 VAC, 60 Hz, 1.5 – 2.5 Amps.
 - 2. Fuse rating: T, 5 Amps, 250 Volts.
- C. Product and Manufacturer: Provide one of the following:
 - 1. Model LDO with SC100 Controller and Air Blast Assembly as manufactured by Hach.
 - 2. Or equal.

2.26 pH/ORP SENSOR AND TRANSMITTER

- A. Type: Continuous monitoring system consisting of pH/ORP sensor and a micro-processor-based analyzer/transmitter designed to measure pH/ORP of the sample and produce a proportional output signal linear to the pH/ORP.
- B. Performance:
 - 1. Sensor:

- a. Range: 0 to 14 pH/(-)500 to (+)500 or 0 to 1000 millivolts.
 - b. Response Time: 95 percent of full scale in five seconds.
2. Analyzer/Transmitter:
- a. Range: Same as sensor.
 - b. Sensitivity: 0.05 percent of span.
 - c. Repeatability: 0.05 percent of span.
 - d. Stability: 0.05 percent of span for 24 hours, non-cumulative.
 - e. Outputs: 4 to 20 mA DC direct acting and isolated into 0 to 1000 ohms at 24 VDC power supply.
 - f. Ambient Temperature Range (Transmitter): -22 degrees F to 122 degrees F.
 - g. Ambient Relative Humidity: 0 to 90 percent RH non-condensing.
- C. Construction Features:
1. Sensor:
- a. Body: Polyvinylidene DiFluoride (PVDF) or PEEK.
 - b. Electrodes: pH and reference electrodes to be contained in sensor body.
 - c. Sensor to contain thermistor for process temperature correction.
 - d. Sensor to be constructed to allow replenishing of pH 7 buffer in the standard electrode chamber.
 - e. Provide submersible, flow-through or convertible mounting type sensor, as required.
 - f. Cable: PVC jacketed submersible type cable terminated in numbered spade lugs. Provide length as required to connect to remotely mounted transmitter (25 feet minimum length).
 - g. Connection: 3/4-inch NPT female.
2. Analyzer/Transmitter:
- a. Microprocessor-based solid-state circuitry designed for measurement of pH/ORP and transmission of proportional output signal linear to pH/ORP.
 - b. Built-in simulator used in conjunction with front panel controls and display to simulate input parameters and to verify calibration, proper internal functioning of the analog-to-digital conversion, processing, outputs and setting up alarms.
 - c. Front of panel membrane sealed keypad switches for display control and transmitter function control testing and calibration. Unit design and switches shall allow output expansion to 1 pH full-scale span for any part of the range between 0 and 14. Front panel switch shall also allow alternate display of readouts for pH, temperature mV and mA outputs.
 - d. Built-in Self-Diagnostics: Error messages shall be presented on the display to indicate operational and equipment malfunctions. Operational errors shall include questionable calculation results, insufficient data, excessive input noise, input measurement, or calculated results out of range. Equipment problems shall include read-only memory fails check

sum, random-access memory problem, identification error, card in wrong position, switch failure, wrong or no input card.

- e. Indicator: 4-1/2 digit LCD indicator with measurement unit and configuration constant identifiers; 7/8-inch high digits.

 NTS: DESIGN PROFESSIONAL SHALL INSERT THE CORRECT NUMBER AND TYPE OF DIGITAL ALARMS BASED ON THE MODEL OF TRANSMITTER BELOW.

- f. Alarm Outputs: (--Dual alarm, Selectable Lo-Hi, Hi-Hi, Lo-Lo. Normally open and normally closed contacts rated ten amp, 24 VDC/250 VAC--).
- g. Housing: Thermoplastic, weatherproof, NEMA 4X enclosure with transparent vision panel for viewing the indicator and controls and equipped with brackets to allow for handrail, surface mounting or pipe stand mounting.
- h. Power Supply: 120 VAC, 60 Hz, 15 watts.

 NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MODEL NUMBERS AND INSERT AT NO. 1 TO NO. 4 BELOW.

- D. Product and Manufacturer: Provide one of the following:
 - 1. Model (--1--) Analyzer/Transmitter and (--2--) sensor, as manufactured by Rosemount.
 - 2. Model (--3--), as manufactured by Hach / Great Lakes.
 - 3. Model (--4--), as manufactured by Siemens.

2.27 RESIDUAL CHLORINE ANALYZER AND TRANSMITTER

 NTS: THIS UNIT REQUIRES A SAMPLE LINE AND DRAIN.

- A. General: Unit shall use amperometric analysis to analyze and indicate total chlorine residual in a sample piped to the unit.
- B. Required Features:
 - 1. Type: Amperometric.
 - 2. Accuracy: ±Two percent of calibrated span.
 - 3. Sensitivity: 0.001 mg/L or 1/2 percent of full scale, whichever is greater.
 - 4. Repeatability: 0.001 mg/L or one percent of full scale range, whichever is greater.

5. Stability: \pm One percent of full scale for one month.
6. Response Speed: 90 percent of change within 60 seconds after sample entry.
7. Output Signal: Isolated 4 to 20 mADC.
8. Piping Connections: 3/4-inch female NPT sample line, 1-1/4-inch female NPT drain connection.
9. Temperature: 33 degrees F to 120 degrees F. Provide automatic compensation for sample temperature.
10. Enclosure: ABS cabinet, NEMA 4X.
11. Power: 120 VAC \pm ten percent.
12. Display: Multi-line LED display.
13. Operator Keypad Menu:
 - a. mg/L total residual.
 - b. Cell current in microamps.
 - c. Sample temperature in degrees F or C.
 - d. Feed rate in ml/hr.
 - e. High and low alarm setpoints.
 - f. Backflush cycles per day.
 - g. Output signal in mADC.
 - h. Access code status.
14. Accessories: Include sufficient, quantities for one year operation assuming bi-monthly calibration. Include drain hose, pH test papers, potassium iodide and tube of grit.

 NTS: DESIGN PROFESSIONAL SHALL SELECT THE APPROPRIATE MODEL NUMBERS AND INSERT AT NO. 1 AND NO. 2 BELOW.

- C. Product and Manufacturer: Provide one of the following:
1. Model (--1--), as manufactured by Wallace & Tiernan.
 2. Model (--2--), as manufactured by Hach.
 3. Or equal.

2.28 CHLORINE ANALYZER AND TRANSMITTER

- A. General: Unit shall use colorimetric analysis to analyze and indicate free or total chlorine residual in a sample piped to the unit.
- B. Required Features:
1. Type: Colorimetric.
 2. Accuracy: \pm Five percent of calibrated span.
 3. Sensitivity: 0.005 mg/L or 5 percent of full scale, whichever is greater.
 4. Response Speed: One complete sample analysis every 2-1/2 minutes.
 7. Output Signal: Isolated 4 to 20 mADC.
 8. Piping Connections: 1/4-inch OD polyethylene tube as the sample line with a quick disconnect fitting, 1/2-inch ID flexible hose drain connection.

9. Temperature: 33 degrees F to 120 degrees F. Provide automatic compensation for sample temperature.
10. Enclosure: ABS plastic, IP-62 rated with gasketed door latched.
11. Power: 120 VAC \pm ten percent, 60 Hz.
12. Display: Multi-line custom LCD display.
13. Alarm Relay Outputs: Two alarms selectable for sample concentration alarm, analyzer system warning, or analyzer system shut-down alarm.

 NTS: DESIGN PROFESSIONAL SHALL SELECT THE APPROPRIATE MODEL NUMBER AND INSERT AT NO. 1 BELOW.

- C. Product and Manufacturer: Provide one of the following:
 1. Model (--1--), as manufactured by Hach.
 2. Or equal.

2.29 SUSPENDED SOLIDS AND/OR TURBIDITY SENSOR AND TRANSMITTER

- A. General: Meter uses a dual beam infrared / scattered light photometer method to determine turbidity in the fluid flowing pipes or open channels. The meter shall have no moving parts and shall allow for continuous monitoring. An LED light source will transmit a beam of infrared light into the sample stream at an angle of 45 degrees to the sensor face. A pair of photoreceptors in the sensor face shall detect the scattered light at 90 degrees to the transmitted beam.
- B. Required Features:
 1. Type: Infrared / scattered light.
 2. Accuracy: Less than 1% of reading or \pm 0.001 NTU for turbidity; less than 5% of reading for suspended solids.
 3. Detection Limit: 0.001 NTU or 1 mg/L.
 4. Repeatability: Less than one percent of reading for turbidity; less than 3% of reading for suspended solids.
 5. Response Speed: Initial response in one second and signal average time to range, based on user selection, from 1 to 300 seconds.
 6. Insertion mounting of sensor in pipes: Through the sidewall of a pipeline using a ball valve; minimum pipe size 4" in carbon or stainless steel.
 7. Cable Length: 33' standard with optional extension cables.
 8. Temperature: 32 degrees F to 104 degrees F.
 9. Sensor Construction: Stainless Steel or PVC.
 10. Flow velocity: A maximum of 9.8 ft/s (3 m/s).
 11. Power: 120 VAC \pm ten percent.
 12. Transmitter Display: LCD display.
 13. Output: 4-20 mA DC

- C. Product and Manufacturer: Provide one of the following:

1. Model Solitax SC probe with SC100 Controller, as manufactured by Hach.
2. Or equal.

2.30 DENSITY MEASUREMENT SYSTEM

- A. General: Density meter uses microwave phase difference method to determine concentrations of solids in the fluid flowing pipes. The density meter shall have no moving parts and shall allow for continuous monitoring. The density meter shall calculate density based on programmed calibration curve and provide a 4 to 20 mADC output. The density meter and converter panel shall be supplied by the same manufacturer.
- B. Required Features:
1. General:
 - a. Measurement Method: Microwave phase difference.
 - b. Span: 1 to 10 percent total solids (TS).
 - c. Repeatability: \pm Two percent full scale for the span two percent TS or above; and, \pm four percent full scale for the span below two percent TS.
 - d. Linearity: \pm Two percent full scale for the span two percent TS or above; and, \pm four percent full scale for the span below two percent TS.
 - e. Electrical Resolution: 0.005 percent TS.
 - f. Measurement Cycle: Average value of 100 measurements at a 0.05 second interval is output every five seconds.
 - g. The meter shall not be affected by fluid velocity and not have any upstream or downstream requirements.
 - h. The cable length between the meter and converter shall be minimum 30 feet long.
 2. Detector:
 - a. Meter Size: As shown on the Drawings.
 - b. Connection: ANSI 150 lb Flange.
 - c. Fluid Temperature: 32 degrees F to 120 degrees F and the meter shall have temperature compensation.
 - d. Wetted Material:
 - 1) Pipe: Type 316 Stainless Steel.
 - 2) Temperature Detector Sheath: Type 316 Stainless Steel.
 - 3) Applicator Window: Hard Vinyl Chloride.
 - 4) Applicator Sealant: Chloroprene rubber.
 - e. Enclosure Rating: IP 63.
 - f. Power Requirements: 24 VDC from converter.
 3. Converter:
 - a. Output: Isolated 4 to 20 mADC, load resistance 750 ohm maximum. Output shall be configurable to be forced to 4 mA when the sensor detects a partially filled pipe.
 - b. Alarms: 120 VAC, 0.1 A (resistive load) dry contact; opens when an error occurs or when maintenance work is in progress.

- c. Arresters: Surge arresters installed in density meter current output (4 to 20 mADC) and AC power lines.
- d. Power Supply: 120 VAC, 60 Hz.
- e. Enclosure Rating: IP 63.
- f. Mounting: Standard wall mounted installation include all fastener hardware.

 NTS: DESIGN PROFESSIONAL SHALL SELECT THE APPROPRIATE MODEL NUMBER AND INSERT AT NO. 1 BELOW.

- C. Product and Manufacturer: Provide the following:
 - 1. Model (--1--), as manufactured by Toshiba.
 - 2. Or equal.

2.31 COMPOSITE SAMPLERS

- A. General: Automatic composite samplers shall be furnished and installed as shown on the Drawings. Sampler shall collect, composite and preserve by refrigeration, uniform liquid samples. Sampler shall consist of a corrosion-resistant weatherproof housing enclosing the sampling chamber collection mechanism, refrigeration system and electrical controls.
 - 1. Number of Samplers Required:

 NTS: DESIGN PROFESSIONAL SHALL INSERT THE APPROPRIATE EQUIPMENT NUMBER AND LOCATION IN THE TABLE BELOW.

Equipment No.	Installation Location

- B. Type: Automatic sampling system, which supports both timed and flow quantity operation.
- C. Required Features:
 - 1. Cabinet: Fiberglass reinforced plastic with beige UV inhibited polymer laminate.

2. Sample Pump: High speed peristaltic dual roller, with 3/8-inch I.D. by 5/8-inch O.D. Dow Corning Silastic Rx50 medical grade silicone rubber pump tube.
3. Vertical Lift: 27-feet maximum.
4. Pump Flow Rate: 60 ml/sec at 3-foot vertical lift in a 3/8-inch I.D. intake tube.
5. Liquid Sensors: Dual sensors, non-wetted, non-contact.
6. Sample Volume: Programmed in milliliters, in one ml increments from 10 to 9,999.
7. Sample Volume Repeatability: +/- 5%
8. Sample Bottle Capacity: Two 3-gallon polyethylene.
9. Sampling Modes: Multiple bottle time, multiple bottle flow, composite multiple bottle time, composite multiple bottle flow, composite time, composite flow, flow with time override, variable interval, start/stop, and level actuation.
10. Interval Between Samples: Selectable in single increments from 1 to 9,999 flow pulses (momentary contact closure 25 msec. or 5 to 12 VDC pulse; 4 to 20 mADC interface optional), or 1 to 9,999 minutes in one minute increments.

 NTS: DESIGN PROFESSIONAL SHALL SELECT THE APPROPRIATE MODE OF OPERATION.

11. Multiplex: Multiple bottle mode of operation, multiple samples per bottle and/or multiple bottles per sample collection.
12. Intake Purge: Air purged automatically before and after each sample; duration automatically compensated for varying intake line lengths.
13. Control Panel: 21 key membrane switch keypad with four multiple function soft keys; 8 line x 40 character alphanumeric, backlit liquid crystal graphic display, self prompting/menu driven program.
14. Internal Clock: Indicated real time and date; 0.007 percent time base accuracy.
15. Diagnostic: Tests keypad, display, ROM, pump, and distributor.
16. EPROM Flash Memory: Via RS232 and modem.
17. Manual Sample: Initiates a sample collection independent of program in process.

 NTS: DESIGN PROFESSIONAL SHALL SELECT THE APPROPRIATE NUMBER OF RINSES AT NO. 1. DESIGN PROFESSIONAL SHALL SELECT THE APPROPRIATE NUMBER OF TIME FOR THE SAMPLE COLLECTION TO BE REPEATED PRIOR TO AN ALARM BEING ISSUED AT NO. 2.

18. Intake Rinse: Intake line automatically rinsed with source liquid prior to each sample, from 0 to (--1--) rinses.
19. Intake Fault: Sample collection cycle automatically repeated from 0 to (--2--) times if sample not obtained on initial attempt. If failure persists an alarm shall be issued.
20. Multiple Program: Stores up to five sampling programs.
21. Data logging: Records program start time and date, up to 400 sample collection.
22. Set Point Sample Trigger: Sampling can be triggered upon an upset condition when field selectable limits are exceeded. Concurrent with normal sampling routine, sample liquid is deposited in designated "trouble bottles".
23. Program Languages: English.
24. Program Lock: Access code protected.
25. Internal Battery: Maintains program logic and real time clock for five years.

D. Controls: The sampler shall provide from its local controller panel the capability to select between periodic and flow quantity sampling. In time sampling mode, the controller shall provide for a programmable interval timer. In flow quantity sampling mode, the controller shall integrate a 4-20 mA varying flow signal until a programmed flow quantity has been obtained. Once the timer has elapsed in the time interval mode of operation or the flow quantity equals the preset amount in flow quantity mode of operation, the controller shall command a peristaltic pump to run for programmed amount of time and obtain a volume of sample. The sampler controller shall provide for programmable adjustment of the sample time duration which controls the sample volume..

E. Product and Manufacturer: Provide the following:

1. Model Sigma 900 MAX, as manufactured by Hach / American Sigma.
2. Or equal.

2.32 LOWER EXPLOSION LIMIT (LEL) SENSOR AND TRANSMITTER

 NTS: DESIGN PROFESSIONAL SHALL INSERT THE APPROPRIATE GAS AND LOCATIONS AT NO .1 AND 2.

A. General: Combustible Gas Transmitters for the detection of (--1--) shall be provided to monitor ambient gas concentration in (--2--). Each gas transmitter shall consist of an explosion-proof electronic transmitter with close coupled combustible gas sensor. For outdoor locations or for all units supplied with the Auto-Test generator, a splash guard shall be supplied for the sensor. .

B. Performance Requirements:

1. Combustible Gas Sensor:
 - a. Type: Catalytic oxidation.

- b. Auto Test: Housing to contain an electrochemical hydrogen generator for the Auto-Test function.
 - c. Output: Held during Auto-Test function and dropped to 3 mA if the sensor fails the Auto-Test.
 - d. Sensor Guard: Required for moisture protection.
 - e. Enclosure: 316 Stainless Steel and Explosion proof.
2. Transmitter:
- a. Power: Operate from 12-24 VDC and shall be capable of driving external loads up to 1000 ohms.
 - b. Display: LCD to display concentration in % LEL.
 - c. Controls: Four magnetic controls to allow calibration functions.
 - d. Enclosure: Explosion-proof enclosure with a window.
 - e. Ratings: To meet specifications for Class 1, Group B, C, and D; Class 2, Groups E and F; Class 3 locations.

 NTS: DESIGN PROFESSIONAL SHALL THE CORRECT MODELS NUMBERS AT NO. 1.

- C. Products and Manufacturers: Provide one of the following:
- 1. Model (--1--), as manufactured by Analytical Technology Incorporated (ATI).
 - 2. Or equal.

2.33 SULFITE SENSOR AND TRANSMITTER

 NTS: DESIGN PROFESSIONAL SHALL INSERT THE APPROPRIATE LOCATIONS AT NO .1.

- A. General: Residual Sulfite Monitors shall be supplied for continuous measurement of the residual sulfite at the (--1--). The sulfite monitoring system shall consist of and electronic monitor, a chemistry module containing a gas phase sulfite sensor, pumps and associated accessories.
- B. Performance Requirements:
- 1. Sulfite Monitor:
 - a. Power: Operate from 110/220 VAC.
 - b. Range: 0 – 2.0 or 0 – 20.00 PPM.
 - c. Accuracy: +/- 0.03 PPM.
 - d. Repeatability: +/- 0.01 PPM.
 - e. Display: 16 character alphanumeric backlit LCD.
 - f. Control Relays: Two SPDT relays, 5A @ 220 VAC resistive programmable deadband and time delay.

- g. Control Mode: On/Off, pulse width modulation, pulse frequency modulation.
 - h. Alarm Relay: Programmable for actuation on high/low values or system failure.
 - i. Analog Output: Isolated 4-20 mA, 600 ohm maximum load.
 - j. Enclosure: Panel mount standard, NEMA 4X (IP-65) wall mount optional.
2. Chemistry Module:
- a. Sensor: Membraned SO₂ gas sensor.
 - b. Sensor Cable: 25 ft standard, 100 ft maximum.
 - c. Response Time: 95% in 3 minutes.
 - d. Sample Pump: Internal tubing pump, 5 cc/min.
 - e. Acid Pump: Internal tubing pump, 0.06 cc/min.
 - f. Air Supply: Diaphragm air pump with precision flow control
 - g. Air Stripping: Cast Acrylic
 - h. Sample Flow: 3-30 gph at sample.
 - i. Sample Inlet: ¼" ID hose barb.
 - j. Sample Drain: ½" ID hose barb.
 - k. Power: 120/220 VAC 60/50 Hz

 NTS: DESIGN PROFESSIONAL SHALL INSERT THE CORRECT MODEL NUMBER AT NO. 1.

- C. Products and Manufacturers: Provide one of the following:
- 1. Model (--1--), as manufactured by Analytical Technology Incorporated (ATI).
 - 2. Or equal.

2.34 NITRATE / NITRITE SENSOR AND TRANSMITTER

A. The method of measuring ammonia will be by measuring the absorption of Ultraviolet (UV) light. A built-in photometer will measure the primary UV 210-nm beam and a second beam of UV light at 350-nm will provide the reference standard and correct for interference caused by turbidity and organic matter.

 NTS: DESIGN PROFESSIONAL SHALL CHOOSE THE APPROPRIATE PARAMETERS AND INSERT THE CORRECT MODEL NUMBER FOR THE PROBE AT NO. 1. BELOW.

- B. Performance Requirements
- 1. Measurement range (depending on model):
 - a. 0.1 to 100 mg/L NO₂₊₃-N or
 - b. 1.0 to 20 mg/L, NO₂₊₃-N or

- c. 0.5 to 20 mg/L, NO₂₊₃-N.
- 2. Detection limit (depending on model):
 - a. 0.1 to 100 mg/L NO₂₊₃-N or
 - b. 1.0 to 20 mg/L, NO₂₊₃-N or
 - c. 0.5 to 20 mg/L, NO₂₊₃-N.
- 3. Accuracy (depending on model):
 - a. ± 3% of the mean ± 0.5 or
 - b. ± 5% of the mean ± 1.0 or
 - c. ± 5% of the mean ± 0.5
- 4. Reproducibility (depending on model):
 - a. 2% ±0.05 mg/L, or
 - b. 2% ±1.0 mg/L, or
 - c. 2% ±10 mg/L
- 5. Response time: 15 seconds to 5 minutes (depending on model).
- 6. Measurement interval: 15 seconds to 15 minutes (depending on model).
- 7. Operating Temperature: 36 to 104⁰ F
- 8. Cable Length: 10 m (32.8 ft)
- 9. Output Signal: 4-20 mA DC
- 10. Transmitter Power: 120 VAC, 60 HZ

C. Product and Manufacturer: Provide the following:

- 1. Nitratex Model (--1--) UV Nitrate Sensors with SC100 Controller, as manufactured by Hach.
- 2. Or equal.

2.35 AMMONIA ANALYZER AND TRANSMITTER

- A. The method of measuring ammonia will be by gas sensitive electrode (GSE) that uses liquid to gas-phase conversion to expel and measure ammonia concentration.
 - 1. Sample is mixed with sodium hydroxide that converts all ammonium to ammonia which is expelled from the sample.
 - 2. Ammonia gas is re-dissolved in an indicator reagent, changing the pH value to produce a color change.
 - 3. A colorimeter measures the color change of the solution and the reading is converted to ammonia concentration.
- B. Performance Requirements
 - 2. Measurement range (depending on model):
 - a. 0.05 to 20 mg/L, or
 - b. 1 to 100 mg/L, or
 - c. 10 to 1000 mg/L
 - 2. Lower detection limit (depending on model):
 - a. 0.05 mg/L, or
 - b. 1 mg/L, or
 - c. 10 mg/L
 - 3. Accuracy (depending on model):
 - a. 3% ±0.05 mg/L, or

- b. 3% \pm 1.0 mg/L, or
 - c. 4.5% \pm 10 mg/L
 - 4. Reproducibility (depending on model):
 - a. 2% \pm 0.05 mg/L, or
 - b. 2% \pm 1.0 mg/L, or
 - c. 2% \pm 10 mg/L
 - 5. Response time: Less than 5 minutes (T90), including sample preparation.
 - 6. Measurement interval: 5 to 120 minutes, adjustable.
- C. Operational Criteria
- 1. Ammonia analyzer:
 - a. Sample temperature: 39 to 104 degrees F
 - b. Sample pH: 5 to 9 pH
 - c. Operating temperature: -4 to 114 degrees F
 - d. Operating humidity: 95% relative humidity, non condensing
 - 2. Filtration system:
 - a. Immersion depth: 9.8 feet (3 m), maximum
 - b. Sample flow rate: 3 m/s, maximum
 - c. Filtrate flow rate: 5 mL/minute, minimum
- D. Equipment
- 1. Ammonia analyzer:
 - a. The analyzer shall calibrate and clean itself automatically.
 - b. The analyzer shall be equipped with self-diagnostic routines.
 - c. The required power supply shall be 230 Vac/50Hz or optional 115 Vac/50-60Hz connected to a multi-parameter universal controller.
 - d. Data transmission shall be made with a data cable with the controller.
 - e. Outputs shall include relay, current outputs, and bus interface via the controller.
 - 2. Filtration system:
 - a. The system provides in-situ filtration.
 - b. The required power supply is via the analyzer 100 VA (brief peak power consumption 1000 VA) and electrical fuse protection.
 - c. Filter modules are exchangeable.
 - d. Continuous self-cleaning with air bubbles.
 - e. Particles larger than 0.15 μ m are separated from the sample stream.
 - f. Available with 5 or 10 m heated filter probe hose
- E. Product and Manufacturer: Provide the following:
- 1. Amtax SC Ammonia Analyzer with the Filterprobe SC Filtration System and SC1000 Controller, as manufactured by Hach.
 - 2. Or equal.

2.36 PORTABLE MULTI-GAS MONITOR

- A. General: The portable meters shall be capable of detecting the presence of oxygen, combustibles, hydrogen sulfide and carbon monoxide.
- B. Performance Requirements:
 - 1. Digital display.
 - 2. Audible and visual alarms for instantaneous readout, short term exposure and long term exposure.
 - 3. Vibration alarm for use in high noise applications.
 - 4. Battery Operation: A rechargeable either Lithium-Ion or an Alkaline battery. Batteries shall be suitable for a minimum of ten hours of operation.
- C. Products and Manufacturers: Provide one of the following:
 - 1. MultiPro Gas Detector, as manufactured by Biosystems.
 - 2. Solaris Gas Detector, as manufactured by MSA.
 - 3. Or equal.

2.37 INTRINSIC SAFETY DEVICES

- A. General: Intrinsic Safety Isolator shall integrate transformer isolation, intrinsic safety barrier circuits, signal conditioning and diagnostic capabilities into one device. Device shall eliminate noise, ground loop problems and provide intrinsic safety without a high integrity ground connection.
- B. Performance Requirements:
 - 1. Environmental Conditions: -4 degrees F to 140 degrees F
 - 2. Mounting: 35 mm DIN rail.
 - 3. Connections:
 - a. Intrinsic safety side: blue plug-in screw terminal blocks.
 - b. Safe area side: green plug-on screw terminal blocks.
 - c. Wire size: 14 AWG to 24 AWG.
 - 4. Housing Material: Polyamide PA non-reinforced.
 - 5. Location of Unit: Rated for Class 1 Div 2 (Groups A, B, C, D)
 - 6. Indicators: LED indicators for power, signal status and line fault detection.

 NTS: DESIGN PROFESSIONAL SHALL THE CORRECT MODEL NUMBER AT NO. 1.

- C. Products and Manufacturers: Provide one of the following:
 - 1. Model (--1--), as manufactured by Phoenix Contact
 - 2. Or equal.

2.38 SLUDGE BLANKET LEVEL MONITOR

- A. Type: Continuous monitoring system consisting of a microprocessor controller, a sonic transducer/transceiver assembly with a hinged mounting arm, and all interconnecting cables.

- B. Probe Requirements:
 - 1. Resolution: 0.09 feet.
 - 2. Accuracy: ± 0.33 feet.
 - 3. Range: 0.6 to 40 feet.
 - 4. Measurement Interval: 10 to 600 seconds (adjustable).
 - 5. Operating Temperature Range: 35 degrees F to 122 degrees F.
 - 6. Probe Construction:
 - a. Wiper: Silicon
 - b. Body: Stainless Steel
 - c. Face: Polyoxymethylene.

- C. Transmitter Features:
 - 1. Output: Two 4 to 20 mADC signals.
 - 2. Alarms: Three user configurable alarm set point relays with SPDT contact outputs rated at five amps, 120 VAC resistive.
 - 3. LCD display with LED backlighting.
 - 4. NEMA 4X / IP66 metal enclosure.
 - 5. Memory Backup: All user settings to be retained in memory.
 - 6. Power Requirements: 100 to 230 VAC, 50/60 Hz.

NTS: DESIGN PROFESSIONAL SHALL THE CORRECT MODEL NUMBERS AT
NO. 1 AND 2.

- D. Product and Manufacturer: Provide one of the following:
 - 1. Model (--1--) Sludge Blanket Level Probe with a Model (--2--) Controller, as manufactured by Hach.
 - 2. Or Equal.

2.39 SPARE PARTS AND TEST EQUIPMENT

- A. Furnish and deliver the spare parts and test equipment as outlined below, identical to and interchangeable with similar parts furnished under this Section.

- B. Spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

NTS: DESIGN PROFESSIONAL SHALL COORDINATE WITH THE COUNTY REGARDING THE EXACT QUANTITY AND ITEMS OF SPARE PARTS. SECTIONS C AND D NEED TO BE EDITTED FOR EACH PROJECT.

- C. The following shall constitute the minimum spare parts:
 - 1. Five of each type input-output relay for each 40 or less furnished for this Contract.
 - 2. One replacement power supply for each type and size furnished for this Contract.
 - 3. A one-year supply of all expendable materials.
 - 4. One per five of gauges, indicators and/or switches used in field complete with diaphragm seals, filled and ready for use.
 - 5. Provide one per ten, or part thereof, per range of field instruments including all insertion type instruments. No spares are required for in-line instruments such as magnetic flow meters and venturis that include flow tubes through which the flow passes.
 - 6. One dozen of each type and size of fuse used in instruments.

- D. The following shall constitute the minimum test and calibration equipment.
 - 1. All tooling required to insert, extract and connect any internal or external connector, including edge connectors.
 - 2. All special calibration equipment required for system calibration.
 - 3. A calibrator for magnetic flow transmitters.

- E. All spare parts shall have been operated and tested in the factory as part of factory testing prior to shipment of the control system.

- F. For process sensors and all other analog instruments, the supplier shall submit a separate quotation for a recommended list of spare parts and test equipment. Each item recommended shall be listed and priced separately. The spare parts quotation shall contain a statement that the prices quoted are firm for a period of one year from the installation date of the equipment, and that the supplier understand that the OWNER reserves the right to purchase none, any, or all of the parts quoted. The supplier is required to show that a stock of spare parts and test-equipment is obtainable within a 48-hour period.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. CONTRACTOR shall require the system supplier to furnish the services of qualified factory-trained servicemen to assist in the installation of the instrumentation and control system equipment.

- B. Install each item in accordance with manufacturer's recommendations and in accordance with the Contract Documents. Transmitters and instruments, which require access for periodic calibration or maintenance, shall be mounted so they are accessible while standing on the floor. Care shall be taken in the installation to ensure sufficient space is provided between instruments and other equipment or piping to allow for easy removal and servicing.
- C. All items shall be mounted and anchored using stainless steel hardware, unless otherwise noted.
- D. All field instruments shall be rigidly secured to walls, stands or brackets as required by the manufacturer and as shown.
- E. Conform to all applicable provisions of the NEMA standards, NEC and local, State and Federal codes when installing the equipment and interconnecting wiring.

3.2 START-UP, CALIBRATION, TESTING, AND TRAINING

- A. Comply with the requirements of Section 13401, SCADA System - General Requirements, Section 13403, SCADA System - Startup and Field Testing, and Section 13404, SCADA System - Training.

3.3 RANGES AND SET POINTS

NTS: DESIGN PROFESSIONAL SHALL FILL THE TABLE WITH CORRECT INFORMATION BELOW FOR ALL THE INSTRUMENTS SPECIFIED IN THIS SPECIFICATION.

Location	Description	Loop No.	Range / Set point	Comments

++ END OF SECTION ++

SECTION 13430

SCADA SYSTEM
PANELS AND ENCLOSURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish, install, calibrate, test, start-up and place into satisfactory operation all control panels and enclosures.

B. Related Sections:

NTS: DESIGN PROFESSIONAL SHALL LIST BELOW ONLY SECTIONS AND DIVISIONS COVERING PRODUCTS, CONSTRUCTION AND EQUIPMENT THAT A USER MIGHT EXPECT TO FIND IN THIS SECTION, BUT ARE SPECIFIED ELSEWHERE. THE ADMINISTRATIVE AND PROCEDURAL DIVISION 1 SECTIONS SHALL NOT BE LISTED.

1. Section (--1--), Excavation and Backfill.
2. Section (--1--), Anchorage in Concrete.
3. Section (--1--), Cast-In-Place Concrete.
4. Section 13401, SCADA System, General Requirements.
5. Section 13402, SCADA System, Factory Testing.
6. Section 13403, SCADA System, Start-up and Field Testing.
7. Section 13440, SCADA System, Panel Instruments and Devices.
8. Section 13491, SCADA System, Control Descriptions
8. Division 16, Electrical.

1.2 QUALITY ASSURANCE

A. Standards, Codes and Regulations:

1. Construction of panels and the installation and interconnection of all equipment and devices mounted within shall comply with applicable provisions of the following standards, codes and regulations:

- a. National Fire Protection Association 79, Annex "D" Standards, (NFPA).
 - b. National Electrical Code, (NEC).
 - c. National Electrical Manufacturer's Association Standards, (NEMA).
 - d. American Society for Testing and Materials, (ASTM).
 - e. Operational Safety and Health Administration Regulations, (OSHA).
 - f. Underwriters' Laboratory, Inc., (UL).
 - g. State and Local code requirements.
 - h. Where any conflict arises between codes or standards, the more stringent requirement shall apply.
2. All materials and equipment shall be new and all panels shall be built in an Underwriters' Laboratory, Inc. (UL) approved panel shop and bear the UL label.

 NTS: DESIGN PROFESSIONAL SHALL COORDINATE WITH THE PROJECT CONTRACT REGARDING IF CONTROL DESCRIPTIONS WILL BE INCLUDED WITH THE CONTRACT DOCUMENTS AND EDIT PART 2 ACCORDINGLY.

B. General Design Requirements:

- 1. Comply with the requirements of Section 13401, SCADA System, General Requirements.
- 2. Comply with the Control Descriptions of Section 13491, SCADA System, Control Descriptions.

C. Factory Assembly and Testing:

- 1. Comply with the requirements of Section 13402, SCADA System, Factory Testing.

1.3 SUBMITTALS

- A. Comply with the requirements of Section 13401, SCADA System, General Requirements.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Comply with the requirements of Section 13401, SCADA System, General Requirements.

PART 2 - PRODUCTS

2.1 GENERAL CONSTRUCTION REQUIREMENTS

- A. Provide all electrical and/or pneumatic components and devices, support hardware, fasteners, interconnecting wiring and/or piping required to make the control panels and/or enclosures complete and operational.
- B. Locate and install all devices and components so that connections can be easily made and that there is ample room for servicing each item.
- C. Components for installation on panel exterior shall be located generally as shown. Layouts shall be submitted for review in accordance with Section 13401, SCADA System, General Requirements.
- D. Where permitted by location and layout as shown, panels and enclosures shall have full height rear and front access doors. Where rear doors are not possible, panels shall have full front access doors.
- E. Adequately support and restrain all devices and components mounted on or within the panel to prevent any movement.
- F. Provide sub-panels for installation of all relays and other internally mounted components.
- G. All wiring to panel connections from field instruments, devices, and other panels shall be terminated at master numbered terminal strips, unless otherwise specified.
- H. Provide copper grounding studs for all panel equipment.
- I. Provide the following convenience accessories inside of each control panel:
 - 1. One 120 VAC, 20A duplex, grounding type receptacle.
 - 2. One or more 120 VAC fluorescent light fixtures with 40 watt lamp and protective plastic shield to span across the width of the panel but not less than two-thirds the width of the panel, as a minimum.
 - 3. One 120 VAC, 20A, snap switch, to turn on the light, mounted in an outlet box with a cover and located so that it is easily accessible from access door.
 - 4. Service light with switch and duplex receptacle shall have its own circuit breaker and separate power feed.
- J. The bottom 12-inches of free standing panels shall be free of all devices, including terminal strips, to provide ease of installation and testing.
- K. No device shall be mounted less than 36-inches above the operating floor level, unless otherwise specified.

2.2 IDENTIFICATION

NTS: DESIGN PROFESSIONAL SHALL COORDINATE WITH THE OWNER'S
STANDARDS OR ADD MATCH EXISTING NAMEPLATES AND TAGS, IF
REQUIRED.

- A. Provide laminated plastic nameplates for identification of panels and components mounted thereon as follows:
 - 1. Nameplates shall be of 3/32-inch thick laminated phenolic type with black matte finish surface and white letter engraving.
 - 2. Panel identification nameplates to have 1/2-inch high letter engravings.
 - 3. Panel mounted component (e.g., control devices, indicating lights, selector switches, etc.) identification nameplates to have 1/4-inch high letter engravings.
 - 4. Nameplates shall be attached to the panel face with two stainless steel self-tapping screws.
 - 5. Nameplate engravings shall include the instrument or equipment tag number and descriptive title as shown and specified.

- B. Tag all internally mounted instruments in accordance with the following requirements:
 - 1. Tag numbers shall be as listed in the Contract Documents.
 - 2. The identifying tag number shall be permanently etched or embossed onto a stainless steel tag which shall be fastened to the device housing with stainless steel rivets or self tapping screws of appropriate size.
 - 3. Where neither of the above fastenings can be accomplished, tags shall be permanently attached to the device by a circllet of 1/16-inch diameter stainless steel wire rope.
 - 4. Identification tag shall be installed so that the numbers are easily visible to service personnel.
 - 5. Front of panel mounted instruments shall have the tag attached to rear of device.

- C. Tagging of the following items shall be accomplished with the use of adhesive plastic Brady USA, Inc. labels, or equal.
 - 1. Tag all electrical devices (e.g., relays, timers, power supplies) mounted within control panels and enclosures.
 - 2. Tag all pneumatic lines.
 - 3. Numerically tag all terminal blocks.
 - 4. Numerically tag wiring at each end.

2.3 PANELS AND ENCLOSURES

- A. General:
 - 1. Panels and enclosures shall meet the NEMA requirements for the type specified.

2. Sizes shown on the Contract Drawings are estimates. CONTRACTOR shall furnish panels and enclosures amply sized to house all equipment, instruments, front panel mounted devices, power supplies, power distribution panels, wiring, tubing and other components installed within, as required.

B. Construction Features:

1. Control panels located inside control or electrical room areas shall be NEMA 12 rated.
 - a. Fabricate enclosures using minimum 14-gage steel for wall or frame mounted enclosures and minimum 12-gage for free standing enclosures. Steel shall be free of pitting and surface blemishes.
 - b. Continuously weld all exterior seams and grind smooth. Also, surface grind complete removal of corrosion, burrs, sharp edges and mill scale.
 - c. Reinforce sheet steel with steel angles where necessary to adequately support equipment and ensure rigidity and to preclude resonant vibrations.
 - d. Panel shall be flat within 1/16-inch over a 24-inch by 24-inch area, or flat within 1/8-inch for a larger surface. Flatness shall be checked by using a 72-inch long straight edge. Out-of-flatness shall be gradual, in one direction only, and shall not consist of obvious depressions or a series of wavy sections.
 - e. Use pan type construction for doors. Door widths shall not exceed 36-inches.
 - f. Mount doors with full-length heavy-duty piano hinge with stainless steel hinge pins.
 - g. Provide oil resistant gasket completely around each door or opening.
 - h. Provide handle-operated, oil-tight, key-lockable three-point stainless steel latching system with rollers on latch-rods for easy door closing.
 - i. Use stainless steel fasteners throughout.
 - j. Provide interior mounting panels and shelves constructed of minimum 12-gage steel with a white enamel finish.
 - k. Provide steel print pocket with white enamel finish.
 - l. Provide enclosure mounting supports as required for floor, frame, or wall mounting.
 - m. Provide all holes and cutouts for installation of conduit and equipment. Cable and piping to enter the enclosure through the bottom, unless otherwise noted. All conduit and piping openings and all conduits shall be sealed watertight.
 - n. Completely clean all interior and exterior surfaces so they are free of corrosive residue, oil, grease and dirt. Zinc phosphatize for corrosion protection.
 - o. One coat of primer shall be applied to all interior and exterior surfaces immediately after corrosion protection has been applied. Exterior surfaces shall then be given sufficient coats of primer surfacer, applied with sanding and cleaning between coats, until a Grade 1 finish can be produced on the finish coat.

- p. All interior surfaces shall be painted with two coats of semi-gloss white polyurethane enamel.
 - q. All exterior surfaces shall be painted with a minimum of three finish coats of polyurethane enamel to ultimately produce a Grade 1 finish (super smooth; completely free of imperfections). Color to be selected by ENGINEER from complete selection of standard and custom color charts furnished by the manufacturer. Provide one extra quart of touch-up paint for each exterior finish color.
 - r. Primer and finish paint shall be compatible and shall be a low VOC, high solids polyurethane enamel, Hi-Solids Polyurethane B65 W300 Series as manufactured by Sherwin-Williams, Inc. or equal.
 - s. Provide one extra quart of touch-up paint for each exterior finish color.
2. Control panels located in field shall be NEMA 4X rated.
- a. Panels shall be Type 316L stainless steel construction with a minimum thickness of 12-gage for all surfaces (except those areas requiring reinforcement) having a smooth brushed finish.
 - b. Stainless steel screw clamp assemblies on three sides of each door.
 - c. Rolled lip around three sides of door and along top of enclosure opening.
 - d. Hasp and staple for padlocking.
 - e. Provide a clear plastic, gasketed lockable hinged door to encompass all non-NEMA 4 front of panel instruments.
 - f. Provide 3-inch high channel base assembly, with solid bottom, drilled to mate the panel to its floor pad.
 - g. Floor Pad: Refer to Part 3 of this Section.
3. Field Panels (NEMA 7):
- a. General: Explosion-proof control enclosures shall be used to house monitoring and measuring devices in hazardous environments. Enclosures shall be suitable for use in NEC Class 1, Groups C and D or Class II, Groups E, F and G applications and comply with UL and CSA standards.
 - b. Required Features:
 - 1. Light weight and corrosion resistant copper-free aluminum.
 - 2. Integral, cast-on mounting lugs.
 - 3. Left side door hinges.
 - 4. Viewing windows sized to suit internally mounted components.
 - 5. Stainless steel cover bolts.
 - 6. Cad-plated steel mounting pans.

 NTS: DESIGN PROFESSIONAL TO INSERT OTHER MANUFACTURERS OF PANELS
 AT NO. 1.

- c. Manufacturers: Provide explosion-proof control enclosures of one of the following:

1. Hoffman.
 2. (--1--).
5. Where the application applies and with the approval of ENGINEER, wall mounted enclosures may be provided. The enclosure shall comply with Paragraph B.1., or B.2., except for the following:
- a. Locations shall be as shown on or as specified under other Sections.
 - b. Panels may be all fiberglass, polycarbonate or ABS.
 - c. Doors shall be full height.
 - d. Corrosion resistant polyester quick release latches shall be provided.
 - e. No extra holes or knockouts shall be provided. No light or convenience outlet need be provided.

C. Electrical Systems:

 NTS: DESIGN PROFESSIONAL TO NOT PROVIDE STRIP HEATERS IN
 POTENTIALLY HAZARDOUS LOCATIONS.

1. Control of Environment:
 - a. Outdoor Panels:
 - 1) Provide automatically controlled closed loop ventilation fans or closed loop air conditioners with filtered air louvers if required to maintain temperature inside each enclosure below the maximum operating temperature rating of the components inside the enclosure. Air conditioner shall have a minimum capacity of 4,000 BTU. Housing shall be constructed of corrosion resistant materials.
 - 2) Provide thermostats to automatically control heating and cooling requirements without need of manual operation of a heating/cooling transfer switch.
 - 3) Provide documentation if any of the above is deemed unnecessary.
 - b. Indoor Panels:
 - 1) Provide automatically controlled closed loop ventilation fans or closed loop air conditioners with filtered air louvers if required to maintain temperature inside each enclosure below the maximum operating temperature rating of the components inside the enclosure. Air conditioner shall have a minimum capacity of 4,000 BTU.
 - 2) Provide documentation if any of the above is deemed unnecessary.
2. Power Source and Internal Power Distribution:
 - a. General: Control panel power supply source, type, voltage, number of circuits and circuit ratings shall be as shown.
 - b. Panels shall be provided with an internal 120 VAC power distribution panel with number of circuits and separate circuit breakers sized as required to distribute power to the panel components. Distribution panel shall contain two spare breakers, minimum.

3. Wiring:
 - a. Internal wiring shall be Type MTW and THHN stranded copper wire with thermoplastic insulation rated for 600 V at 90°C for single conductors, color coded and labeled with wire identification.
 - b. For DC panel signal wiring, use No. 18 minimum AWG shielded.
 - c. For DC power wiring, use No. 12 minimum AWG. For AC signal and control wiring, use No. 16 minimum AWG. For wiring carrying more than 15 A, use sizes required by NEC standards.
 - d. Separate and shield low voltage signal wiring from power and control wiring by a minimum of 6-inches.
 - e. Group or bundle parallel runs of wire using covered troughs. Maximum bundle size to be 1-inch. Troughs shall have 40 percent spare capacity.
 - f. Install wire troughs along horizontal or vertical routes to present a neat appearance. Angled runs are not acceptable. Wire ways to be manufactured by Panduit or equal.
 - g. Adequately support and restrain all wiring runs to prevent sagging or other movement.
 - h. Terminate all field wiring using compression type connectors (soldered type not acceptable) at 600 V rated barrier type terminal strips and permanently affixed numeric identifiers beside each connection. Identifiers to be self-stick plastic tape strips with permanent type, machine printed numbers. For DC field signal wiring, terminal strips shall be capable of handling No. 12 wiring (minimum). Provide terminal blocks manufactured by Weidmuller.
 - i. All wiring shall be installed such that if wires are removed from any one device, power will not be disrupted to any other device.
 - j. All alarms generated external to the panel, spare alarm, and repeat contacts shall be wired out to terminal blocks.
 - k. For internal component-to-component wiring only, compression type terminal blocks are acceptable.
 - l. Provide spare terminals equal in number to 20 percent of the terminals used for each type of wiring (e.g., DC signal and AC power).
 - m. Provide a separate terminal for grounding each shielded cable.
 - n. Use separate 5/16-inch diameter copper grounding studs for instrument signal cable shields and AC power.
 - o. Where wires pass through panel walls, provide suitable bushings to prevent cutting or abrading of insulation.
 - p. When DC power and/or low voltage AC power is required, provide and install the necessary power supplies and transformers in the panel.
 - q. Provide fused terminal blocks, which will provide an LED indicator for a blown fuse. Fused terminal blocks shall be manufactured by Schneider Electric / Square D or equal.
 - r. Provide complete wiring diagram showing "as-built" circuitry. Diagram shall be enclosed in transparent plastic and placed in easily accessible pocket built into panel door.

- s. Din Rail shall be manufactured by Weidmuller or equal.
- 4. Surge Protection:
 - a. General: Surge protection shall be provided to protect the electronic instrumentation system from surges propagating along the signal and power supply lines. The protection systems shall be such that the protection level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, and be maintenance free and self-restoring. Instruments shall be housed in suitable metallic cases, properly grounded. Ground wires for all surge protectors shall be connected to a good earth ground and where practical each ground wire run individually and insulated from each other. These protectors shall be mounted within the instrument enclosure or a separate junction box (compatible with the area designation) coupled to the enclosure.

 NTS: DESIGN PROFESSIONAL SHALL COORDINATE WITH THE OWNER'S STANDARDS OR MATCH EXISTING MANUFACTURERS, IF REQUIRED.

- b. Manufacturer:
 - a. Telecommunication Industries, Inc., Joslyn.
 - b. (--1--)
 - c. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install equipment in conformance with NEC.
- B. Unless otherwise noted, install indoor NEMA 4X panels on 4-inch concrete pad. Extend pad 4-inches beyond outside dimensions of base, all sides. Lay grout after panel sills have been securely fastened down.

 NTS: DESIGN PROFESSIONAL TO INSERT CORRECT SPECIFICATION SECTIONS AT NO.S 1 THROUGH 3.

- C. Unless otherwise noted, install outdoor NEMA 4X panels on a reinforced concrete pedestal:
 - 1. Minimum Thickness: Eight-inches with No. 4 steel reinforcing bars at 12-inches on centers, each way.
 - 2. Minimum Size: Twelve-inches larger than outer dimensions of base, all sides.

3. Provide excavation and backfill work in conformance with Section (--1--), Excavation and Backfill.
 4. Provide concrete work in conformance with Section (--2--), Cast-In-Place Concrete.
- D. Install anchor bolts and anchor in accordance with Section (--3--), Anchorage in Concrete.
- E. Install and interconnect all equipment, devices, electrical hardware, instrumentation and controls and process controller components into and out of and among the enclosures as indicated on the Drawings.
- F. Provide a sunshade for all field panels and instruments as shown on the Contract Drawings.

3.2 TESTING AND ADJUSTMENTS

- A. Perform system testing and make any adjustments necessary in accordance with this Section, Section 13401, SCADA System, General Requirements, Section 13402, SCADA System, Factory Testing, and Section 13403, SCADA System, Start-up and Field Testing.
- B. Perform power supply, voltage adjustments to tolerances required by the appurtenant equipment.

+ + END OF SECTION + +

1.3 SUBMITTALS

- A. Comply with the requirements of Section 13401, SCADA System, General Requirements.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Comply with the requirements specified in Section 13401, SCADA System, General Requirements.
- B. Instruments and devices shall not be assembled in the panels until all product information and system Shop Drawings for respective components have been approved by the ENGINEER and OWNER.

1.5 IDENTIFICATION TAGS

- A. All panel instruments and devices shall have an identification tag meeting the following requirements:
 - 1. Tag numbers shall be as listed in the Contract Documents.
 - 2. Identifying tag number shall be permanently etched or embossed onto a stainless steel tag which shall be fastened to the device housing with stainless steel rivets or self tapping stainless steel screws of appropriate size.
 - 3. Where neither of the above fastenings can be accomplished, tags shall be permanently attached to the device by a circllet of 1/16-inch diameter stainless steel wire rope.
 - 4. All instruments and devices mounted within panels shall have the stainless steel identification tag installed so that the numbers are easily visible to service personnel. Front of panel mounted components shall have the tag attached to the rear of the device.
 - 5. Front of panel mounted components shall have nameplates, which comply with the requirements specified in Section 13430, SCADA System, Panels and Enclosures.

PART 2 - PRODUCTS

NTS: BELOW IS A TABLE OF CONTENTS FOR USE AS A GUIDE. DESIGN PROFESSIONAL TO ADD OR DELETE THE ARTICLES NOT USED AND RE-NUMBER THE ARTICLES WITHIN THIS SECTION. DESIGN PROFESSIONAL SHALL CONSULT WITH COUNTY REGARDING ALL THE MANUFACTURERS AND THE TERM "OR EQUAL" FOR EACH DEVICE.

2.1 Power Supplies.

- 2.2 Uninterruptible Power System.
- 2.3 Pushbuttons, Selector Switches and Indicating Lights.
- 2.4 Digital Indicator.
- 2.5 Analog Indicator.
- 2.6 Current to Pressure Convertor.
- 2.7 Cycle Timer.
- 2.8 Electronic Totalizer and Integrator.
- 2.9 Elapsed-Time Meter (Hour meter).
- 2.10 Single Loop Digital Controller (SLDC).
- 2.11 Triple Loop Digital Controller (TLDC).
- 2.12 Control Relay.
- 2.13 Time Delay Relay.
- 2.14 Current Alarm Relay.
- 2.15 Current Isolator.
- 2.16 Current and Voltage Transducer.
- 2.17 Vibration and Temperature Monitoring System.
- 2.18 Electronic Recorder (Paperless Type).
- 2.19 Annunciator System.
- 2.20 Electronic Horn.
- 2.21 Automatic Telephone Dialer.
- 2.22 Ethernet Radio.
- 2.23 Serial Radio.
- 2.24 Antenna.
- 2.25 Solar Power Systems.
- 2.26 Communications Cable and Connectors.
- 2.27 Data Handler.
- 2.28 Universal WEB Station (UWS).
- 2.29 Spare Parts and Test Equipment.

2.1 POWER SUPPLIES

- A. General: Single unit and multiple unit power supplies, located in control room panels, remote terminal units and field panels as required.

 NTS: SELECT PARAGRAPH "B" FOR SINGLE OR PARAGRAPH "C" UNIT, AS
 REQUIRED.

- B. Single Unit Required Features:
 - 1. Solid state circuitry.
 - 2. DIN Rail mounting.
 - 3. Input Power: 120 VAC \pm 10 percent, 60 Hz.
 - 4. Output Power: 24 VDC or as required.
 - 5. Line/Load Regulation: \pm 0.005 percent.
 - 6. Ripple: 0.25 mV RMS.

7. Polarity: Floating output.
8. Ambient Temperature: -4 degrees F to 160 degrees F
9. Response Time: <20μS.
10. Overload Protection: Internal preset.
11. Include mounting brackets, fuse, and mating connector for AC power plug.

C. Multiple Unit Required Features:

1. Solid state circuitry.
2. Standard 19-inch RETMA (EIA) rail mounting.
3. Input Power: 120 VAC ±10 percent, 60 Hz.
4. Output Power: 24 VDC or as required.
5. Polarity: Floating output.
6. Ambient Temperature: 14 degrees F to 160 degrees F
7. Response Time: <20μS.
8. Include over-voltage protection, output current limiting protection, provisions for paralleling power supplies and front panel mounted indicating fuses.
9. If the power supplies are connected in parallel, provide isolation diodes in series with the positive lead of each of the parallel connected power supplies.
10. Connections:
 - a. Twist-lock AC power connector.
 - b. DC power terminal strip.

 NTS: DESIGN PROFESSIONAL TO INSERT CORRECT MODEL NUMBER AT NO. 1.

D. Products and Manufacturers: Provide one of the following:

1. Model (--1--), as manufactured by Sola / Hevi-Duty.
2. Or equal.

2.2 UNINTERRUPTIBLE POWER SYSTEM

 NTS: DESIGN PROFESSIONAL SHALL EDIT FEATURES BELOW DEPENDING ON APPLICATION. FOR EXAMPLE, DURATION FOR POWER SHALL BE INSERTED AT NO. 1.

- A. Uninterruptible Power System (UPS) shall be furnished to provide a reliable source of uninterruptible power with no break in AC output power during a complete or partial interruption of incoming line power. UPS shall include audio/visual alarms. UPS shall be UL listed.
- B. Rating: 120 VAC, 60 Hz, 1.4KVA/1.0KW minimum to provide uninterrupted conditioned power, fully loaded conditions for (--1--) minutes.

C. Description: On line dual track power conditioner and true (0 ms transfer time) uninterruptible power supply providing isolation, line regulation and conditioning, using sealed 48 VDC maintenance free batteries and switch mode power supply for uninterrupted power with 0.5 to 0.7 power factor and 2.7 to 3.5 crest factor.

D. Required Features:

1. Lighting and Surge Protection: Inherent 2000: One spike attenuation.
2. Regulation: One to three percent load regulation with less than 2pF effective coupling capacitance for line to load.
3. Output Waveform: Computer grade sine wave with three percent maximum single harmonic and five percent maximum total harmonic distortion.
4. Output Frequency: 60 Hz \pm 0.5 Hz.
5. Operating Temperature: 34 degrees F to 104 degrees F.
6. Relative Humidity: Five to 90 percent non-condensing.
7. Computer Interface: RS232 port for display of 22 meter functions and 15 alarm functions.
8. Input Protection: Independent battery charger fuse and DC fuses.
9. Output Protection: Inherently current limited ferro-resonant transformer.
10. Battery Charger: Two-step charger, 8 A and 2 A.
11. AC Input: 120 VAC, 60Hz, single phase, +15 percent, -20 percent.
12. AC Output: 120 VAC, 60Hz, single phase, +3 percent, -3 percent.

NTS: DESIGN PROFESSIONAL TO INSERT CORRECT MODEL NUMBER AT NO. 1.

E. Products and Manufacturers: Provide one of the following:

1. Model (--1--), as manufactured by Liebert.
2. Or equal.

2.3 SELECTOR SWITCHES, PUSHBUTTONS AND INDICATING LIGHTS

A. General:

1. Selector switches, pushbuttons and indicating lights shall be supplied by one manufacturer and be of the same series or model type.
2. Type:
 - a. Heavy duty, oil tight.
3. Provide legend plate for indication of each switch, pushbutton or light function (e.g., "OPEN-CLOSED", "HAND-OFF-AUTO").
4. Mounting: Flush mounted on control panel front, unless otherwise noted.
5. NEMA rated to match panel in which mounted.

NTS: DESIGN PROFESSIONAL SHALL EDIT BELOW AS REQUIRED.

B. Selector Switches:

1. Type: Provide selector switches with number of positions as required to perform intended functions as shown and specified.
2. Contacts:
 - a. Provide number and arrangement of contacts as required to perform intended functions specified, but not less than one single pole, double throw contact.
 - b. Type: Double break, silver contacts with movable contact blade providing scrubbing action.
 - c. Rating: Compatible with AC or DC current with devices simultaneously operated by the switch contacts, but not less than 10 A resistive at 120 VAC or DC continuous.
3. Switch Operator: Standard black knob.

C. Pushbuttons (Standard or Illuminated):

1. Type: Provide momentary lighted and/or unlighted, single and/or dual type pushbuttons as required to perform intended functions specified and shown.
2. Contacts: Comply with the requirements specified for selector switches.

D. Indicating Lights:

1. Type: Compact, LED type.
2. Lamps: Six volt, long life (20,000 hours minimum).

NTS: DESIGN PROFESSIONAL SHALL DELETE PARAGRAPH "3" BELOW IF NOT
REQUIRED.

3. Common, push to test circuitry shall be provided for each panel to simultaneously test all indicating lights on the panel using a single pushbutton.

NTS: DESIGN PROEFSSIONAL SHALL COORDINATE COLORS WITH EXISTING
FACILITIES.

E. Button and Lens Colors:

1. Red for indication of open, on, running.
2. Green for indication of closed, off (ready), stopped.
3. Amber for indication of equipment malfunction, process trouble and alarms (e.g., "HIGH LEVEL", "LOW LEVEL", etc.).
4. Blue for indication of electrical control power on.

F. Rotary Cam Switches:

1. Provide rotary cam switches with number of positions and poles as required to perform the required signal switching function specified and shown.

2. Contacts:
 - a. Gold-flashed contacts housed in mechanical contact blocks with number and arrangement of contacts as required to perform intended functions.
 - b. Contact Rating: Compatible with AC or DC through-put current of signals and devices simultaneously operated by the switch contacts, but not less than 20 A at 600 VAC or 250 VDC continuous.
3. Switch Operator: Standard black knob.

 NTS: DESIGN PROFESSIONAL SHALL INSERT CORRECT MODEL OR SERIES NUMBERS AT NO. 1 AND 2.

G. Products and Manufacturers: Provide one of the following:

1. Model (--1--), as manufactured by Eaton Electrical
2. Series (--2--), as manufactured by Cutler Hammer.
3. Or equal.

2.4 DIGITAL INDICATOR

A. General: The digital indicator shall accept an analog input and convert it to scaled numerical characters for digital display and also provide up to two alarm outputs.

B. Required Features:

1. Display Height: 0.56-inch.
2. Display Capacity: Four digits with decimal point position jumper selectable.
3. Display Type: Seven segment, red LED.
4. Accuracy: ± 0.05 percent.
5. Analog Input: 4 to 20 mADC.
6. Excitation Output: 15 VDC for powering transmitter.
7. Analog Output: Proportional 4 to 20 mADC.
8. Alarm Output: Dual with two 2 A relays.
9. Temperature Range: 32 degrees F to 140 degrees F
10. Power: 120 VAC, + 10 to -15 percent, five watts.
11. Enclosure: NEMA 4 splash proof.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBERS AT NO. 1 & 2.

C. Products and Manufacturers: Provide one of the following:

1. Model (--1--), as manufactured by Red Lion.
2. Or equal.

2.5 ANALOG INDICATOR

- A. General: Indicator Unit shall be a signal monitoring instrument that provides continuous monitoring of a process variable on a scaled vertical bar display. Indicator shall match in appearance other panel mounted instruments.
- B. Description: Indicator Unit shall display one process variable.
- C. Required Features:
 - 1. Input Signals: 1 to 5 VDC (into 10 megohm) or 4 to 20 mADC (into 250 ohm range resistor).
 - 2. Power Required: 21 to 28 VDC; nominal input current at 24 VDC is 400 mA.
 - 3. Displays: One segmented gas-discharge or LED vertical bar display.
 - 4. Display Accuracy: One percent of input span.
 - 5. Scale Length: Approximately 3-inches.
 - 6. Operating Influences:
 - a. Ambient Temperature: Maintains display accuracy ratings for temperature change within normal operating conditions.
 - b. Supply Voltage: Maintains display accuracy ratings for supply voltage variation between 21 and 28 VDC.
 - c. Electromagnetic Interference (EMI): Maintains display accuracy ratings when instrument is subjected to an electromagnetic field of up to ten volts/meter (when rack-mounted in cabinet with door closed). Display station must be installed in panel.
 - 7. Operating Conditions:
 - a. Ambient Temperature: 41 to 122 degrees F.
 - b. Maximum Temperature Variation: 36 degrees F per hr.
 - c. Ambient Relative Humidity: Ten to 90 percent non-condensing.
 - 8. Mounting: Display station installs in a nominal 1-inch by 6-inch panel cutout and shall match in appearance other panel mounted instruments.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBER AT NO. 1.

- D. Products and Manufacturers: Provide one of the following:
 - 1. Model (--1--), as manufactured by Red Lion.
 - 2. Or equal.

2.6 CURRENT TO PRESSURE CONVERTOR

- A. General: Unit shall convert a current signal to pneumatic signal so that an electronic-based system such as a PLC can control a pneumatic actuator, valve or damper drive.
- B. Construction Features:
 - 1. Supply Pressure: Negligible from 20-40 psig, steady pressure.

2. Repeat Accuracy: Less than +/- 0.25% of span.
3. Air Consumption: 0.08 SCFM.
4. Air Supply: Instrument air only; 20-40 psig.
5. Voltage Drop: 7.5V, maximum
6. Ambient Conditions: -40 degrees F to + 176 degrees F.
7. Adjustments: Screw adjusts zero or span by +/- 10% minimum, non-interactive.
8. Connections:
 1. Electrical: Removable front-mounted terminal blocks, 22-14 AWG.
 2. Pneumatic: 1/8-inch NPT female for both supply air and output air on units with optional mounting block.
9. Indicators: RED LED to indicate presence and intensity of electrical input.
10. Power Input: 4-20 mA, 4-12 mA or 12-20 mA.
11. Housing: DIN rail, WTI rain-proof as defined by NEMA 3R or NEMA 4

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBER AT NO. 1.

- C. Products and Manufacturers: Provide one of the following:
 1. Model (--1--), as manufactured by Moore Industries.
 2. Or equal.

2.7 CYCLE TIMER

- A. Type: Adjustable, microprocessor-based multipurpose timer/counter.
- B. Construction Features:
 1. Switch selectable ranges as follows:
 - a. 0 to 0.99 seconds.
 - b. 0 to 99.9 seconds.
 - c. 0 to 999 seconds.
 - d. 0 to 9.99 minutes.
 - e. 0 to 99.9 minutes.
 - f. 0 to 999 minutes.
 - g. 0 to 99.9 hours.
 - h. 0 to 999 hours.
 2. Repeat Accuracy:
 - a. Timer: ±10 ms on all ranges.
 - b. Counter: 100 percent on all ranges.
 3. Memory: Non-volatile memory that will retain entire program and present time/count periods at loss of power; programmable for both reset and non-reset power fail operation.
 4. Operating Temperature: 32 to 140 degrees F.
 5. Cycle Progress Display: Three-digit display, programmable to run up to or down from the setpoint and to stop or continue up from zero after time-out/count-out.

6. Time/Count Periods: Three programmable presets; pulse, early and main.
7. Load Relays:
 - a. Type: DPDT.
 - b. Number: One early and one delayed.
 - c. Contact Ratings: Seven amps at 120 VAC.
8. Terminals: Screw terminals accessible at rear.
9. Housing: Fully gasketed, dust and watertight.
10. Power Input: 120 VAC.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBER AT NO. 1.

- C. Products and Manufacturers: Provide one of the following:
 1. Model (--1--), as manufactured by Automatic Timing and Controls Company.
 2. Or equal.

2.8 ELECTRONIC TOTALIZER AND INTEGRATOR

- A. General:
 1. Electronic integrator shall be a solid-state device to totalize a linear flow signal with respect to time. The integrated output shall be indicated on a front counter, calibrated to read directly in units of flow and shall be mounted on the panel face.
- B. Required Features:
 1. Modular plug-in design.
 2. Variable dropout adjustment shall be provided to prevent erroneous counting at low flow rates.
 3. Input Signal: 4 to 20 mADC.
 4. Power Requirements: 120 VAC \pm 10 percent, 60 Hz.
 5. Accuracy: 0.5 percent of rate between 10 and 100 percent of full scale.
 6. Slide-out chassis.
 7. Suitable for flush panel mounting.
 8. Unit shall match in appearance other panel mounted instruments.
 9. Integrator Output Display:
 - a. Integrally mounted six or eight-digit LCD.
 - b. Non-reset.
 - c. Battery backed to prevent loss of display in the event of power outages.
 10. Enclosure: NEMA 4X.
 11. Ambient Operating Temperature: 32 degrees F to 130 degrees F.
 12. Ambient Operating Humidity: 0 to 85 percent non-condensing.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBERS AT NO. 1 & 2.

C. Products and Manufacturers: Provide one of the following:

1. Model (--1--), as manufactured by Foxboro.
2. Model (--2--), as manufactured by Precision Digital.
3. Or equal.

2.9 ELAPSED TIME METER (HOUR METER)

A. General: Unit shall be a powered, non-resettable time indicator, with easy to read analog figures.

NTS: DESIGN PROFESSIONAL SELECT POWER REQUIREMENTS BELOW.

B. Required Features:

1. Power: 120 VAC, or 4 to 40 VDC.
2. Accuracy: Within one percent.
3. Capacity: Up to 99,999.9 hours (automatic recycle at zero); one-tenth hour resolution.
4. Operating Temperature: -40 degrees F to 155 degrees F.
5. Sealed against dirt and moisture.
6. Tamperproof.
7. Shock resistant.
8. Panel mountable.
9. Nameplate below display shall read "TOTAL HOURS".

NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBERS AT NO. 1 & 2.

C. Products and Manufacturers: Provide one of the following:

1. Series (--1--), as manufactured by Danaher Industrial Controls Group.
2. Series (--2--), as manufactured by Eaton Electrical.
2. Or equal.

2.10 SINGLE LOOP DIGITAL CONTROLLER (SLDC)

A. General: Separate, Single Station Electronic Indicating (Single Loop) Controllers shall be provided for executing stand-alone, automatic regulatory loop control as shown. The controllers shall match in appearance other panel mounted instruments.

B. Type: Microprocessor-based controller with single loop integrity and user configuration capability.

C. Required Design and Construction Features:

1. Modular Construction.
2. Front panel LED, gas-discharge or vacuum-fluorescent type, user configurable displays as follows:
 - a. Two vertical bar graphs with percentage scales; capability to provide direct reading scales, insertable without tools, shall be available.
 - b. Digital readout display, four digits (minimum) with decimal point and minus sign typically for display of the engineering unit values associated with the two vertical bar graphs.
 - c. One horizontal bar graph with 0 to 100 percent scale or an auxiliary 4-digit (minimum) digital indicator display, typically for output value.
3. Front panel pushbuttons or membrane type keypad controls for the following:
 - a. Digital display selector.
 - b. Remote-Ratio/Local setpoint mode selector.
 - c. Automatic/Manual output control selector permitting bumpless, balanceless transfer.
 - d. Raise/Lower setpoint adjustments.
 - e. Increase/Decrease manual output adjustments.
4. Discrete Status Indicators for the following:
 - a. Indication of values displayed on the digital readout display.
 - b. Indication of remote or local setpoint mode.
 - c. Indication of automatic or manual mode of operation.
 - d. Process alarm limit indication of two separate alarm limit settings.
5. Mounting Requirements: Designed for flush panel mounting; suitable for single and multiple case mounting.
6. Power Requirements: Unit shall be designed to operate on nominal 24 VDC power provided by an external panel/instrument power supply. Lithium battery backup shall be provided for controller memory.
7. Input/Output Capabilities:
 - a. Analog Inputs:
 - 1) Type: 4 to 20 mADC current signals and 1 to 5 VDC signals.
 - 2) Quantity: Three, minimum.
 - 3) Resolution: 12 bit binary (± 0.025 percent).
 - 4) Accessories: Provide auxiliary signal isolators where output controls more than one device.
 - b. Analog Outputs:
 - 1) Type: 4 to 20 mADC.
 - 2) Quantity: Two separate outputs, minimum.
 - 3) Accessories: Provide auxiliary signal isolators when output controls more than one device.
 - c. Digital Inputs:
 - 1) Type: 0 to 15 VDC logic level.
 - 2) Quantity: Two, minimum.
 - 3) Accessories: Provide auxiliary interposing relays when required to interface higher level control/ status/ alarm input signals.
 - d. Digital Outputs:

- 1) Type: Solid state, open-collector transistor type, logic level outputs (30 VDC maximum).
 - 2) Quantity: Two, minimum.
 - 3) Accessories: Provide auxiliary interposing relays when required to provide higher level control/status/ alarm outputs.
8. Microprocessor Sampling and Update Rates:
 - a. PID and Control Program Execution Rate: Program executed once per 0.1 seconds.
 - b. Input Signal Sampling Rate: 0.1 seconds.
 - c. Display Update: 0.1 seconds.
 - d. Output Signal Update: 0.1 seconds.
 9. Required Operational and Functional Capabilities:
 - a. Processing capability for a minimum of one PID control loop with analog input signal conditioning, and remote setpoint and ratio control functions.
 - b. Anti-reset windup.
 - c. Ramp setpoint capability.
 - d. Output limiting.
 - e. Alarming (absolute process and deviation).
 - f. Calculation Functions:
 - 1) Addition.
 - 2) Subtraction.
 - 3) Multiplication.
 - 4) Division.
 - 5) Square Root.
 - g. Ratio Control.
 - h. Lead/Lag.
 - i. Override control via remote inputs and/or internal program logic.
 - j. Totalization capability.
 - k. Digital logic operations.
 - l. On-Off digital output control.
 - m. Configurable power fail-auto restart in previous mode at last output or in manual at a preset output.
 - n. Balanceless and bumpless control transfer between all operating modes.
 - o. Internal operating diagnostics to detect hardware malfunctions, memory error, loss of input and low memory battery backup voltage.
 10. Communication Capability: Unit shall be designed to permit bidirectional communication with other controllers and a supervisory control system and/or host computer utilizing a RS-422 Serial Communication link.
 11. Configuration Capability and Accessories:
 - a. Controller shall be user-configurable by means of a portable, hand-held configurator terminal or from the controller front keypad upon entry of a security code password. The hand-held terminal shall plug directly into the front panel of the controller.
 - b. Controllers shall be completely pre-configured by the instrumentation and control system supplier to perform the control algorithms and functions shown and/or specified.

- c. Controller configuration shall be capable of being copied and transported by either of the following methods:
 - 1) Portable, battery-backed RAM memory module or NOVRAM module with copy accessory installed in controller and capable of both copying and loading the controller configuration database.
 - 2) External, portable programming terminal with tape cassette or disc drive for off-line programming, editing, and copying of configurations and block downloading of configurations to the connected controller.
 - d. One portable, hand-held configurator terminal shall be supplied with the controllers.
12. PID Control Range Adjustment:
- a. Proportional Band: 0 (off) to 1000 percent.
 - b. Integral: 0.04 seconds to 100 minutes and off.
 - c. Derivative: 0.01 minutes to 100 minutes and off.
 - d. Manual Reset: 0 to 100 percent.
13. Connections: Provide compression type terminals for power and signal line connections.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBER AT NO. 1.

- D. Products and Manufacturers: Provide one of the following:
- 1. Series (--1--), as manufactured by Siemens.
 - 2. Or equal.

2.11 TRIPLE-LOOP DIGITAL CONTROLLER (TLDC)

- A. General: Controller shall be a microprocessor-based, stand alone, general purpose instrument designed for process measurement, control and indication of three independent control loops.
- B. Description: Controller shall provide analog bargraph displays dedicated to process and setpoint values for each of the three loops simultaneously; valve indication; a 4-1/2 digit display for numeric indication; a four character alpha-numeric display; and individual status indicators. Controller shall match in appearance other panel mounted instruments.
- C. Requires Features:
 - 1. Integral keypad switches and pulser knob for configuration and operating functions.
 - 2. Capable of accepting voltage, current, millivolt, thermocouple, RTD, computer pulse, frequency or digital inputs.
 - 3. Current, digital or relay outputs.
 - 4. Separate function blocks to allow input, output, control or computation functions to be individually selected according to application.

5. Loop tag name to be maximum 12 characters as well as four-character process variable engineering unit tag. Tag information pertaining to the selected loop to be scrolled in alphanumeric display by pressing tag pushbutton.
6. Configuration to be done locally at the faceplate for each loop or remotely for the entire station via the Local Instrument Link (LIL) and a personal computer.
7. Capable of being mounted in control panel complete with enclosed casing and provided with access to rear-mounted screw terminals.
8. Operating Conditions:
 - a. Ambient Temperature: 32 to 122 degrees F.
 - b. Relative Humidity: 95 percent.
 - c. RFI Protection: Less than 0.5 percent full scale signal change at RFI field strength of 10V/meter with frequency range from 20 Hz to 1 GHz.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBER AT NO. 1.

- D. Products and Manufacturers: Provide one of the following:
 1. Model (--1--), as manufactured by Siemens.
 2. Or equal.

2.12 CONTROL RELAY

- A. Type: General purpose, plug-in type rated for continuous duty.
- B. Construction Features:
 1. Coil Voltages: 24 VDC or 120 VAC, as required.
 2. Contacts:
 - a. Silver cadmium oxide rated not less than 5 A resistive at 120 VAC or 24 VDC continuous.
 - b. For switching low energy circuits (less than 200 mA) fine silver, gold flashed contacts rated not less than 3 A resistive at 120 VAC or 28 VDC continuous shall be provided.
 3. Relays to have clear plastic dust cover.
 4. Relays to have pilot light to show energized coil.
 5. Relays to be UL recognized.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBER AT NO. 1.

- C. Products and Manufacturers: Provide one of the following:
 1. Series (--1--), as manufactured by IDEC.
 2. Or equal.

2.13 TIME DELAY RELAY

- A. Type: Dial adjustable, plug-in type time delay relay providing delay-on-make, delay-on-break or interval operation.

- B. Construction Features:
 - 1. MOS digital circuit with transformer coupled power.
 - 2. Switch selectable ranges as follows:
 - a. One second.
 - b. Ten seconds.
 - c. One minute.
 - d. Ten minutes.
 - e. One hour.
 - f. Ten hours.
 - 3. Minimum Setting: Three percent of range, except 50 ms for one-second range.
 - 4. Setting Knob Accuracy: Ten percent.
 - 5. Contacts:
 - a. Type: DPDT.
 - b. Rating: 5 A resistive at 120 VAC, 5 A at 24 VDC.
 - 6. Housing: Plug-in design with dust and moisture resistant molded plastic case.
 - 7. Power Input: 120 VAC or 24 VDC as required.
 - 8. Operating Temperature: 32 degrees F to 130 degrees F.
 - 9. Unit shall have LED to show timing status.
 - 10. Relays to be UL recognized.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBERS AT NO. 1 & 2.

- C. Products and Manufacturers: Provide one of the following:
 - 1. Series (--1--), as manufactured by Automatic Timing and Controls Company.
 - 2. Series (--2--), as manufactured by IDEC.
 - 3. Or equal.

2.14 CURRENT ALARM RELAY

- A. Type: Direct current, electronic setpoint control relay which accepts 4 to 20 mADC input signal and provides dry circuit contact output based on trip point setting.

- B. Performance Requirements:
 - 1. Repeatability: Trip point repeats within ± 0.2 percent of span.
 - 2. Trip Adjustment: 0 to 100 percent of span.
 - 3. Adjustable Deadband: 1 to 15 percent of span.

- C. Construction Features:
 - 1. Trip Adjustment: Multi-turn front panel adjustment.
 - 2. Contacts: DPDT relays, rated 5 A at 120 VAC or 24 VDC non-inductive.

3. Enclosure: Standard housing designed for internal panel mounting.
4. Power Supply: 120 VAC, 60 Hz or 24 VDC, as required.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBERS AT NO. 1 & 2.

- D. Products and Manufacturers: Provide one of the following:
1. Series (--1--), as manufactured by Ronan.
 2. Model (--2--), as manufactured by Eurotherm Controls Inc.
 3. Or equal.

2.15 CURRENT ISOLATOR

- A. General: The isolating unit shall be a two wire, loop-powered device. It shall accept a 4 to 20 mADC input signal and deliver a 4 to 20 mADC output.
- B. Required Features:
1. Repeatability: \pm One percent of span.
 2. Ambient Temperature Range: 32 to 122 degrees F.
 3. Ambient Humidity Range: 0 to 95 percent, non-condensing.
 4. Accuracy: 0.5 percent.
 5. Linearity: \pm 0.1 percent of full scale.
 6. Provide one spare isolator.

 NTS: DESIGN PROFESSIONAL INSERT MODEL NUMBERS AT NO. 1 & 2.

- C. Products and Manufacturers: Provide one of the following:
1. Series (--1--), as manufactured by AGM.
 2. Series (--2--), as manufactured by Eurotherm Controls Inc.
 3. Or equal.

2.16 CURRENT AND VOLTAGE TRANSDUCER

- A. General: Transducer shall convert a sinusoidal alternating current or voltage into a DC current output, proportional to the RMS value of input.
- B. Required Features:
1. Inputs: 50/60 Hz.
 - a. Current: 1A or 5A current transformer secondaries.
 - b. Voltage: 50 to 480 VAC.
 2. Output: 4 to 20 mADC into 0 to 500 Ohms.
 3. Zero adjustment: \pm Two percent minimum.
 4. Span adjustment: \pm Ten percent minimum.

5. Accuracy: ± 0.5 percent.
6. Response time: ≤ 400 ms. to 99 percent rated output.
7. Operating Temperature: 32 degrees F to 122 degrees F.
8. Operating Humidity: 0 to 95 percent non-condensing
9. Output Protection: Fully protected against open or short circuit outputs.
10. Overload Capacity: Two times rated current of 1.25 times rated voltage on a continuous basis.
11. Surge Withstand: Conform to ANSI C37-90a.

 NTS: DESIGN PROFESSIONAL INSERT MODEL NUMBERS AT NO. 1.

- C. Products and Manufacturers: Provide one of the following:
1. Series (--1--), as manufactured by Ametek.
 2. Or equal.

2.17 VIBRATION AND TEMPERATURE MONITORING SYSTEM

- A. General: Monitoring system shall be a card cage, rack mountable, instrument system consisting of:
1. Instrument rack.
 2. Analog vibration monitor.
 3. Analog temperature monitor.
 4. Relay modules.
 5. Power supply.
 6. Analog displays.
 7. Transducers.
 8. Interconnecting cable and any other required appurtenances for a completely functional system.
- B. Instrument Rack:
1. Instrument rack shall provide the basic mounting enclosure together with electrical interconnections for the system monitors, relay modules and power supply.
 2. Barrier type terminal strips at the rear shall provide termination points for wiring from panel terminal blocks.
- C. Analog Vibration Monitor:
1. Analog vibration monitor shall plug directly into the instrument rack. The monitor shall contain two complete channels of vibration monitoring each of which shall include two alarms, signal conditioning, transducer power supply, transducer failure detection and a separate bargraph display.
 2. Required Features:
 - a. Front panel or keyboard controls for warning and shutdown setpoints.

- b. Alarm circuitry to continuously monitor vibration warning and shutdown levels in excess of preset limits.
- c. Warning and shut down alarm relay drive signals independent or common to both channels.
- d. Transducer failure relay drive signals common to both channels.
- e. Two vibration signals for inputs.
- f. Adjustable alarm time delay from zero to six seconds.
- g. Temperature Rated: 32 to 110 degrees F.
- h. Relative Humidity Limit: 95 percent non-condensing.
- i. Bargraph: Minimum 50 segment LCD.

D. Analog Temperature Monitor:

- 1. Analog temperature monitor shall plug directly into the instrument rack. Monitor shall continuously monitor a minimum of two and a maximum of twelve RTD inputs.
- 2. Required Features:
 - a. Compatible with standard RTD's.
 - b. Individually adjustable alarm setpoints for each channel.
 - c. LED or LCD indication of alarm conditions.
 - d. Input: Three-wire, 100 ohm platinum transducer.
 - e. Relay drive capability.
 - f. Temperature Rated: 32 to 110 degrees F.
 - g. Relative Humidity Limit: 95 percent non-condensing.
 - h. Input Display: Minimum 50 segment LCD bargraph or four 7-segment LCDs.

E. Relay Modules:

- 1. The relay modules shall plug directly into the instrument rack.
- 2. Required Features:
 - a. Contact Rating: Five amps at 120 VAC.
 - b. Contact Material: Gold flashed.
 - c. Contact Arrangement: Alarm relay to be DPDT; common transducer failure relay to be SPDT.
 - d. Construction: Hermetically sealed metal enclosure.
 - e. Temperature Rated: 32 to 110 degrees F.
 - f. Relative Humidity Limit: 95 percent non-condensing.

F. Power Supply:

- 1. Power supply shall plug directly into the instrument rack.
- 2. Required Features:
 - a. Power: 115 VAC \pm 10 percent, 60 Hz.
 - b. Temperature Rated: 32 to 110 degrees F.
 - c. Relative Humidity Limit: To 95 percent, non-condensing.
 - d. Output: 24 VDC.
 - e. System common reset.
 - f. Power up inhibit.

- g. Alarm relay drive circuitry.
- h. Provide regulated voltages for analog monitors.

G. Vibration Transducer Proximity Type:

- 1. Transducer shall be a non-contacting eddy current, gap-to-voltage transducer which is sensitive to distance, and dynamic change in distance, between the probe tip and the conductive material it is observing.
- 2. Required Features:
 - a. Probe:
 - 1) 8-mm (5-mm trip with protective cover).
 - 2) High Strength Shield: Teflon jacketed lead.
 - 3) Miniature coaxial connector.
 - b. Proximator:
 - 1) Oscillator/demodulator for transducer.
 - 2) Generates RF signal which drives probe.
 - 3) Demodulates returning signal.
 - 4) Provides linear output to monitoring system.
 - 5) Armored, Teflon cable; minimum 25 feet.

H. Acceleration Transducer:

- 1. The acceleration transducer shall consist of a piezo-electric crystal located between the accelerometer base and an internal reference mass, which generates an electric charge upon machine vibration.
- 2. Required Features:
 - a. Accelerometer:
 - 1) Sensitivity: 25 mV/g 0 to peak, ± 5 percent.
 - 2) Acceleration Range: 75 g's peak.
 - 3) Frequency Response: 10 Hz to 20 Hz ± 3 dB.
 - 4) Mounted Resonant Frequency: 30 KHz minimum.
 - 5) Amplitude Linearity: ± 1 percent to 50 g's, \pm percent to 75 g's.
 - 6) Temperature Range: -20 degrees F to 250 degrees F.
 - 7) Relative Humidity: 0 to 95 percent non-condensing.
 - b. Interface Module:
 - 1) Input: -18 to -24 VDC at 15 mA.
 - 2) Output: 100 mV/g.
 - 3) Armored, Teflon cable; minimum 25 feet.

I. Temperature Sensor - RTD Type:

 NTS: DESIGN PROFESSIONAL SHALL INCLUDE RTD SPECIFICATION FROM SECTION 13420, IF REQUIRED.

NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBER AT NO. 1.

- J. Products and Manufacturers: Provide one of the following:
 - 1. Model (--1--), as manufactured by General Electric / Bently Nevada Corporation.
 - 2. Or equal.

2.18 ELECTRONIC RECORDER (PAPERLESS TYPE)

- A. General: The electronic recorder shall be a paperless, microprocessor-based panelboard type, and shall be suitable for flush panel mounting. The electronic recorder shall match in appearance other panel mounted instruments.
- B. Required Features:
 - 1. Power Supply: 120 VAC, 60 Hz.
 - 2. LCD operator's display.
 - 3. Ambient Temperature Range: 32 to 122 degrees F.
 - 4. Scan Time: 500 msec.

NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MEMORY AS REQUIRED.

- 5. Unit memory: 256 KB, 512 KB, 768 KB or 1 MB.

NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE OPTION(S) AND QUANTITIES.

- 6. Voltage Inputs:
 - a. Type: Isolated.
 - b. Range: 0 to 5 VDC.
 - c. Zero: 0 to 1 VDC.
 - d. Span: 4 to 5 VDC.
 - e. Standard Calibration: 1 to 5 VDC.
 - f. Accuracy: ± 0.05 percent of span.
 - g. Maximum Continuous Input: ± 30 VDC.
 - h. Input Impedance: > 1 Meg ohm.
 - i. Quantity: Four (6 optional).
- 7. Universal Inputs:
 - a. Types: J, K, E, T, R, S, B, and N thermocouple; millivolt; voltage (configurable for each input).

- b. Accuracy: ± 0.1 percent of span typical.
 - c. Input Impedance: $> 200,000$ ohms.
 - d. Maximum Continuous Input: ± 30 VDC.
 - e. Resolution: 16-bit.
 - f. Reference Junction Compensation: Automatic.
 - g. Linearization: Automatic.
 - h. Quantity: Six (optional).
8. Optional Digital I/O:
- a. Inputs: Non-isolated 5 VDC contact. ± 30 VDC max. continuous input. 50 msec On/Off time.
 - b. Outputs: Open collector transistor type. 30 VDC (max) load voltage. 100 mA load current.
 - c. Quantity: Eight (optional).
9. Communication Capability: Unit shall be designed to permit bi-directional communication with other controllers and a supervisory control system and/or host computer utilizing a RS-422 Serial Communication link.

C. Calculation and Other Functions:

- 1. Addition.
- 2. Subtraction.
- 3. Multiplication.
- 4. Division.
- 5. Square root.
- 6. 10-segment characterizers.
- 7. Totalization.
- 8. Alarms.
- 9. Delay and one-shot timers.

D. The recorder shall have a PCMCIA drive. Historical data shall be transferred to a PC via a PCMCIA card; 3-1/2-inch disk drives are not acceptable. Local available historical data will be 75 days for each of the four pens based on one-minute time intervals. Provide the following:

- 1. One PCMCIA Memory Card.
- 2. One PC Card Reader.
- 3. Minimum software to analyze four inputs.

 NTS: DESIGN PROFESSIONAL SHALL SELECT APPROPRIATE MODEL BASED ON APPLICATION.

E. Products and Manufacturers: Provide one of the following:

- 1. Model (--1--), as manufactured by Siemens.
- 2. Model (--2--), as manufactured by Yokogawa.
- 3. Or equal.

2.19 ANNUNCIATOR SYSTEM

- A. Performance Requirements:
 - 1. Activate flashing light in module and sound alarm horn(s).
 - 2. Change flashing light to steady light and silence horn(s) by depressing acknowledge pushbutton.
 - 3. Automatically turn off steady light when alarm condition is corrected.

- B. Required Features:
 - 1. Flush panel mounted; NEMA rating to match that of panel in which it is mounted.
 - 2. Solid state integral or remote logic.
 - 3. Plug-in lamp modules including alarm logic circuit boards and filter module, if required.
 - 4. Isolated auxiliary contacts for each alarm point.
 - 5. Front accessible selectors for:
 - a. N.O./N.C. dry field contacts.
 - b. Lock-in/non-lock-in alarms.
 - 6. Yellow lamp test and acknowledge pushbuttons.
 - 7. Horn with adjustable volume control. Mounted within panel if located in control room.
 - 8. Alarm sequence to be ISA sequence 'A'.
 - 9. Single alarm point per window with two lamps per point.
 - 10. Total number of alarm points shall include 20 percent as spares for each system. Future equipment alarms shall not be considered as spares.
 - 11. Spare points shall be provided complete with logic.
 - 12. Windows shall be nominal 3-inch by 3-inch and engraved for all active points in accordance with the Alarm Schedule. Spare point windows shall not be engraved.
 - 13. Character size shall be largest available to allow all information to be shown on window face.
 - 14. Units shall be powered by 120 VAC, 60 Hz and be provided with individual replaceable non-resettable line fuses sized to protect the system.
 - 15. Annunciators shall be provided with internal 24 VDC power supply.
 - 16. On panels with full front access doors where the weight of the annunciator becomes a consideration, remote logic type shall be provided.

NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBERS AT NO. 1 & 2.

- C. Products and Manufacturers: Provide one of the following:
 - 1. Series (--1--), as manufactured by Ametek.
 - 2. Model (--2--), as manufactured by Ronan Engineering Company.
 - 3. Or equal.

2.20 ELECTRONIC HORN

- A. General: The horn shall be of the multi-tone electronic audible type.
- B. Required Features:
 - 1. Internal volume control.
 - 2. Field selection of up to 16 different tones.
 - 3. Power: 120 VAC or 24 VDC (provide power supply as required).
 - 4. Operating Temperature: 32 to 120 degrees F.
 - 5. Enclosure Rating: NEMA 4X.

NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBERS AT NO. 1 & 2.

- C. Products and Manufacturers: Provide one of the following:
 - 1. Model (--1--), as manufactured by Panalarm.
 - 2. Or equal.

2.21 AUTOMATIC TELEPHONE DIALER

- A. General:
 - 1. Dialer shall respond to any change in a monitored condition by automatically executing a series of telephone calls and repeating a pre-programmed human voice message.
 - 2. Dialer shall use standard telephone lines, detect a busy signal and automatically proceed to the next telephone number programmed for the fault.
 - 3. Dialer shall detect a fault via normally open/normally closed contacts.
- B. Required Features:
 - 1. Four digital inputs (up to 32 optional).
 - 2. Power failure alarm.
 - 3. Solid-state message recording.
 - 4. Expandable design.
 - 5. SPST dry contact for fault detection transmission.
 - 6. Auto-answer facility for receiving incoming telephone calls with one to nine ring count.
 - 7. Surge protection on all inputs.
 - 8. Power supply: 120 VAC, 60 Hz.
 - 9. NEMA 4X enclosure.
 - 10. Operating Temperature: 20 degrees F to 130 degrees F.
 - 11. Operating Humidity: 0 to 95 percent non-condensing.
 - 12. Variable message length of each fault.
 - 13. Four digit security code.
 - 14. Internal clock.
 - 15. Remote acknowledge.

16. 16 telephone numbers.
17. Status only indication.
18. Data entry via keyboard and audio input.
19. Automatic "power failure" detection.
20. 20 hour automatically rechargeable battery back-up. Battery operation shall be automatic upon power failure.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBER AT NO. 1.

- C. Products and Manufacturers: Provide one of the following:
1. Series (--1--), as manufactured by Raco.
 2. Or equal.

2.22 ETHERNET RADIO

- A. Provide a complete and functioning spread spectrum radio communications system for Ethernet communications.
- B. Required Features:
1. General:
 - a. Enclosure: NEMA 1; 18 gauge steel.
 - b. Operating Modes: Point-to-Point, Point-to-Multi-Point, Store and Forward Repeater, Repeater/Remote.
 - c. Operating Temp: -4 to 122a degrees F.
 - d. Humidity: 0 to 95% non-condensing.
 - e. Operating Frequency: 902 – 928 MHz.
 2. Transmitter:
 - a. Rated Range: 25 miles using omni directional antenna.
 - b. Installed Range: 35 miles using omni directional antenna.
 - c. Output Power: 1 Watt max.
 - d. Modulation: Spread Spectrum, GFSK.
 - e. Spreading Code: Frequency Hopping.
 - f. Hop Patterns: 15 (user selectable).
 - g. Occupied Bandwidth: 230 KHz.
 3. Receiver:
 - a. Sensitivity: -108 dBm @ 10-6 raw BER.
 - b. Selectivity: 40 dB @ fc +/-230 KHz; 60 dB @ fc +/-460 KHz.
 - c. System Gain: 135 dB.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBER AT NO. 1.

- C. Provide and Manufacturer: Provide the following:

1. Series (--1--), as manufactured by Data-Linc.
2. Or equal.

2.23 SERIAL RADIO

A. Provide a complete and functioning spread spectrum radio communications system for serial communications.

B. Required Features:

1. General:
 - a. Enclosure: NEMA 1; 18 gauge steel.
 - b. Operating Modes: Point-to-Point, Point-to-Multi-Point, Repeater, Store and Forward Repeater.
 - c. Operating Temp: -4 to 122 degrees F.
 - d. Humidity: 0 to 95% non-condensing.
 - e. Operating Frequency: 902 – 928 MHz.
2. Transmitter:
 - a. Rated Range: 25 miles using omni directional antenna.
 - b. Installed Range: 35 miles using omni directional antenna.
 - c. Output Power: 1 Watt max.
 - d. Modulation: Spread Spectrum, GFSK, 144 Kbps – 188 Kbps.
 - e. Spreading Code: Frequency Hopping.
 - f. Hop Patterns: 15 (user selectable).
 - g. Occupied Bandwidth: 230 KHz.
3. Receiver:
 - a. Sensitivity: -108 dBm @ 10⁻⁶ raw BER.
 - b. Selectivity: 40 dB @ fc +/-230 KHz; 60 dB @ fc +/-460 KHz.
 - c. System Gain: 135 dB.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBER AT NO. 1.

- C. Provide and Manufacturer: Provide the following:
1. Series (--1--), as manufactured by Data-Linc.
 2. Or equal.

 NTS: DESIGN PROFESSIONAL SHALL COORDINATE WITH COUNTY AND/OR RADIO STUDY TO DETERMINE THE EXACT TYPE AND NUMBER OF ANTENNAS REQUIRED.

2.24 ANTENNA

A. Required Features:

1. Rated Wind Velocity: 125 mph.
2. Frequency, MHz: 896-960.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBERS AT NO. 1 - 5.

- B. Provide and Manufacturer: Provide the following:
 1. 6Bd Yagi, Series (--1--), as manufactured by Cushcraft/Signals or equal.
 2. 11Bd Yagi, Series (--2--), as manufactured by Cushcraft/Signals or equal.
 3. 4Bd Omni, Series (--3--), as manufactured by Cushcraft/Signals or equal.
 4. 12Bd Directional Omni, Series (--4--), as manufactured by Decibel Products or equal.
 5. 10Bd Omni, Series (--5--), as manufactured by Decibel Products or equal.

2.25 SOLAR POWER SYSTEMS

- A. Package for each location shall consist of one or more 42-watt rated solar panels, voltage regulator/battery charger, overcurrent protection, maintenance free battery system rated for 24 hours of battery operation plus 25% spare capacity, stainless steel mounting assembly, and stainless steel padlockable enclosure for the electronics and battery.
- B. Required Features:
 1. Solar Panel:
 - a. Rated Power: 42 Watts.
 - b. Operating Voltage: 16.5 Volts.
 - c. Operating Current: 2.54 Amps.
 - d. Open Circuit Voltage: 23.8 Volts; 27.1 Volts @ -14 degrees F and 1250 W/m².
 - e. Short Circuit Current: 3.17 Amps; 4.20 Amps @ 167 degrees F and 1250 W/m².
 - f. Series fuse rating: 6.0 Amps.
 - g. Minimum blocking diode: 6.0 Amps.
 2. Battery:
 - a. Nominal Voltage: 12 V.
 - b. Amp-Hours: 65.
 - c. Note: More than 1 battery may be required at the sites to comply with the above 24-hour requirement for all connected components.
 - d. Provided with Absorbed Glass Mat (AGM) technology.
 3. Charger:
 - a. Enclosure: Aluminum Chassis.
 - b. Power Requirements: 110/220 VAC @ 50/60 Hz.
 - c. Output VDC: 12 VDC.
 - d. Output Amps: 6 Amps.

NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBERS AT NO. 1 - 3.

- C. Provide and Manufacturer: Provide the following:
 - 1. Solar Panels: Series (--1--), as manufactured by Uni-Solar.
 - 2. Battery: Series (--2--), as manufactured by Yuasa.
 - 3. Charger: Series (--3--), as manufactured by Deltran.
 - 4. Or equal.

2.26 COMMUNICATIONS CABLE AND CONNECTORS

- A. Communications cable shall be low loss (3.9 dB/100 ft @ 900 MHz) weatherproof coaxial type with aluminum tape outer conductor.
- B. Coaxial protectors shall employ UL497B listed gas tubes, turn-on at 600 VDC +/- 20%, and have an insertion loss <= 0.1 dB over the frequency range.
- C. The antenna transmission line shall have transmission characteristics equal to or better than RG8/U coaxial cable with PL-259 connectors.

NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBERS AT NO. 1 & 2.

- D. Provide and Manufacturer: Provide the following:
 - 1. Communications Cable: Times Microwave Systems LMR-400 or equal.
 - 2. Coaxial Protectors: PolyPhaser Series (--1--) or equal and Polyphase Series (--2-) or equal.

2.27 DATA HANDLER

- A. General: Provide a universal device that conditions converts and logs remote single point analog and digital signals. It also communicates the signals to other locations, operates/controls field devices and interfaces with existing or new peripherals.
- B. Required Features:
 - 1. Power: 9/26 VDC +/- 10%, nominal 200 milliWatts.
 - 2. Operating Temperature Range: -4 to 176 degrees F.
 - 3. Ports: RS232C or optional RS485.
 - 4. Baud Rate: Up to 19200.
 - 5. Inputs: 1 Analog (AC/DC/R/Pulse/TC), 2 dry contacts.
 - 6. Analog Resolution: 13 bits.
 - 7. Outputs: 1 Analog, 4-20 mA DC, 2 dry contacts.
 - 8. Storage: 32K bytes, non-volatile, date/time stamped, event/interval driven.

9. Clock: Yes.
10. Program: 32K bytes.
11. Protocols: ASCII, Modbus (ASCII/Binary), AB-DF1 slave.
12. Connections: AGM Data Handler(s)/Integrated Control Station(s), Dial-up/Cell phone system, PC, fixed frequency/spread spectrum radio modem.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBERS AT NO. 1.

- C. Provide and Manufacturer: Provide the following:
 1. Series (--1--), as manufactured by AGM Electronics.

2.28 UNIVERSAL WEB STATION (UWS)

- A. General: Provide a universal communications interface tool for normalizing and simplifying connectivity to field data. It must include an addressable mini-server that “serves” WEB pages, sends e-mails, accommodates uploading of remotely logged data and supports Supervisory Control from anywhere over the internet.
- B. Required Features:
 1. Power: 12/24 VDC +/- 10%, nominal 3 Watts.
 2. Operating Temperature Range: -4 to 176 degrees F.
 3. Ports: 2 RS232C, 1 RS485, 1 10baseT.
 4. Baud Rate: RS232C/RS485 up to 9600.
 5. Clock: Yes.
 6. Protocols: Ethernet, HTTP, SMTP, FTP, PPP, ASCII, Modbus (ASCII/Binary), AB-DF1 slave.
 7. Connections: AGM Data Handler(s)/Integrated Control Station(s), Dial-up/Cell phone system, PC, fixed frequency/spread spectrum radio modem, cable, satellite, fiber optics.

 NTS: DESIGN PROFESSIONAL SHALL INSERT MODEL NUMBERS AT NO. 1.

- C. Provide and Manufacturer: Provide the following:
 1. AGM Series (--1--), as manufactured by AGM Electronics.

2.29 SPARE PARTS AND TEST EQUIPMENT

- A. CONTRACTOR shall furnish and deliver the spare parts and test equipment as outlined below, all of which shall be identical and interchangeable with similar parts furnished under this Section.

- B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

NTS: DESIGN PROFESSIONAL SHALL COORDINATE THE MINIMUM SPARE PARTS (PART C) AND CALIBRATION EQUIPMENT (PART D) WITH THE COUNTY WITH EACH PROJECT.

- C. The following shall constitute the minimum spare parts:
 - 1. Five of each type of input-output relay for each 40 or less furnished for this Contract.
 - 2. One replacement power supply for each type and size furnished for this Contract.
 - 3. A one-year supply of all expendable materials.
 - 4. One per ten (two, if fewer than twenty) of each type of panel mounted instrument including lights, pushbuttons and PLC equipment.
 - 5. One dozen of each type and size of fuse used in panels and instruments.
- D. The following shall constitute the minimum test and calibration equipment:
 - 1. Three Fluke, Hewlett-Packard, or equal (latest in series), digital multimeter plus amprobe, high voltage probe, test leads, case and all other recommended spares and accessories.
 - 2. All tooling required to insert, extract and connect any internal or external connector, including edge connectors.
 - 3. All special calibration equipment required for system calibration.
 - 4. Two signal simulators (4 to 20 mADC; 1 to 5 VDC), including cases. One simulator shall be battery powered and shall include charger.
 - 5. A Hart portable communicator device.
- E. All spare parts shall have been operated and tested in the factory as part of factory testing prior to shipment of the control system.
- F. For analog instruments, the supplier shall submit a separate quotation for a recommended list of spare-parts and test equipment. Each item recommended shall be listed and priced separately. The spare parts quotation shall contain a statement that the prices quoted are firm for a period of one year (with escalators for the next two years) subsequent to the OWNER'S acceptance of the equipment, and that the supplier understands that the OWNER reserves the right to purchase none, any, or all of the parts quoted. The supplier is required to show that a stock of spare-parts and test equipment is obtainable within a 48-hour period.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install each item in accordance with manufacturers recommendations and in accordance with the Contract Documents.
- B. All items shall be mounted and anchored in compliance with Section 13430, SCADA System, Panels and Enclosures.

3.2 START-UP, CALIBRATION, TESTING AND TRAINING

- A. Comply with the requirements of Section 13403, SCADA System, Startup and Field Testing, and Section 13404, SCADA System, Training.

NTS: DESIGN PROFESSIONAL SHALL LIST ALL THE INSTRUMENTS SPECIFIED
IN THIS SPECIFICATION WITH THE CORRECT RANGES AND SET POINTS IN THE
TABLE BELOW.

3.3 RANGES AND SET POINTS

Area / Location	Description	Loop No.	Range / Set point	Comments

++ END OF SECTION ++

SECTION 13451

SCADA SYSTEM
PROGRAMMABLE LOGIC CONTROLLER
HARDWARE AND SOFTWARE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, software and incidentals as shown, specified and required to furnish and install a fully functional Programmable Logic Controller (PLC) system.
2. PLC or components no longer under full support or being removed from full support by the PLC manufacturer within two years of scheduled installation shall not be acceptable.
3. The hardware required for the PLC is shown on the Contract Drawings and is comprised of the following types of major monitoring processing and control equipment units:

NTS: DESIGN PROFESSIONAL SHALL EDIT EQUIPMENT AS REQUIRED. UPDATE
OPERATING SYSTEM REQUIREMENT PER PROJECT.

- a. Redundant Fiber Optic Communication System.
 - b. Fault tolerant programmable logical controller(s) with local and remote I/O subsystem.
 - d. Peripheral Printers and Projection System.
 - e. Network communication devices, including all required cables and connectors
 - f. Power Supplies.
 - g. Telemetry Units.
 - h. I/O Cards.
 - i. I/O Chassis and Cabling.
4. All software provided for the PLC system shall be Microsoft Windows XP SP2 operating system based. The PLC software provided shall be compatible with the PLC hardware provided. The software required for the PLC is comprised of the following types of components:

NTS: FOR EACH PROJECT, SELECT APPROPRIATE VERSION OF RSLOGIX,
RSLINX AND RSNETWORX.

- a. Latest version of fully licensed PLC programming and configuration software, RsLogix5000 or equal
- b. Latest version of fully licensed communications software and drivers for supplied PLC to PC communication, RSLinx Professional or equal
- c. Latest version of fully licensed network configuration software, RSNetWorx for ControlNet, and Ethernet/IP software with MD or equal

B. Related Sections:

NTS: LIST BELOW ONLY SECTIONS COVERING PRODUCTS, CONSTRUCTION
AND EQUIPMENT THAT A USER MIGHT EXPECT TO FIND IN THIS SECTION, BUT
ARE SPECIFIED ELSEWHERE. DO NOT LIST ADMINISTRATIVE AND
PROCEDURAL DIVISION 1 SECTIONS.

1. Section 13401, SCADA System, General Requirements
2. Section 13430, SCADA System, Panels and Enclosures
3. Section 13452, SCADA System, HMI Hardware and Software
4. Section 13460, SCADA System, Computers and Computer Networks
5. Division 16, Electrical.

1.2 TERMS

- A. The terms listed below are used throughout this Section and are defined as such:
1. Human Machine Interface (HMI): Operator Interface to control system. Allows operator intervention and monitoring of all systems and subsystems connected to the PLC system; usually a desktop computer or industrial hardened computer.
 2. Programmable Logic Controller (PLC): The controlling device used to control and monitor hardware connected to it by way of networks or I/O cards.
 3. Backplane: Usually will indicate the I/O chassis that the power supply, PLC and I/O cards, and network cards reside in.
 4. I/O Cards: Can be either analog or discrete cards that interface between field devices and PLC.
 5. Server: Computer having one or more CPU's used for a specific task such as data depository, web management. Usually connected to the plant network.
 6. Peripheral Devices: Includes, but not limited to, printer(s), display devices and standalone intelligent devices, such as remote HMI stations.
 7. PLC System: Includes all parts listed above.

1.3 QUALITY ASSURANCE

- A. CONTRACTOR shall engage the services of a System Supplier to provide all equipment listed in this Section. The System Supplier shall demonstrate a minimum of five years experience providing PLC systems and be able to show evidence of at least five installations of equal or greater size to the one being specified.

1.4 WARRANTY

 NTS: INCLUDE CLEAR AND CONCISE SPECIAL WARRANTY CONDITIONS UNDER THIS SECTION.

1.5 MAINTENANCE

 NTS: INCLUDE PLC SPARE PARTS, ANY SPECIAL MAINTENANCE SERVICES AND PREVENTIVE MAINTENANCE REQUIREMENTS UNDER THIS SECTION.

- A. The PLC vendor shall provide recommended preventive maintenance tasks, schedules and instructions for hardware supplied. The PM documentation must be clear, applicable to hardware provided, concise and accurate.
- B. Spare Parts: The following spare parts shall be provided, as a minimum, for the PLC System:

 NTS: FOR SMALLER PROJECTS, INCLUDE ACTUAL LIST OF DESIRED SPARE PARTS DIRECTLY IN THIS SECTION.

- a. I/O Modules: To determine the number of spare modules of each type required, the PLC vendor shall use the formula:
 "[(Number of modules required by Contract Drawings) divided by 20, then rounded up to next whole number]"
- b. One of each type PLC processor
- c. One of each type communications module
- d. Two of each type PLC power supply module
- e. Fuses: To determine the number of fuses of each type required, the PLC vendor shall use the formula:
 [(Number of fuses provided with PLC System) divided by 10, then rounded up to next whole number]

PART 2 - PRODUCTS

NTS: RETAIN APPLICABLE SECTIONS LISTED BELOW AS REQUIRED.

2.1 GENERAL

- A. All materials and equipment furnished under this Contract shall be new, free from defects, of first quality, and produced by a manufacturer regularly engaged in the manufacture of these products.
- B. The PLC configuration indicated is diagrammatic. The PLC system shall include as a minimum power supply, network connections, I/O cards, CPU and power supply as shown on the Contract Drawings to achieve the specified functionality.
- C. The final system configuration shall utilize the PLC manufacturer's standard hardware and software to meet the functional requirements of these Specifications.
- D. All equipment furnished under this Contract shall be provided to meet the functional requirements of these Specifications plus a 20 percent growth in project requirements. All equipment shall be provided under this Contract, such that the entire 20 percent project growth can be implemented into the PLC, without any additional hardware cost to the OWNER.
- E. The PLC system shall be capable of being integrated into a larger plant wide PLC communications network system using non-proprietary network communication protocol.

NTS: RETAIN APPROPRIATE COMMUNICATIONS CAPABILITIES AS REQUIRED BY CONTROL SYSTEM NETWORK PCRWRD ACCEPTS ANY OF THE FOLLOWING PLC PROCESSORS. SELECT ONE OR MORE OF THE CONTROLLERS BASED ON THE APPLICATION AND NETWORK COMMUNICATIONS REQUIREMENTS.

2.2 SMALL PROGRAMMABLE LOGIC CONTROLLER

- A. The PLC system should have as a minimum the following features and capabilities:
 - 1. Allen-Bradley Micrologix 1000, 1100, 1200 or 1500
 - 2. Highest user memory available for processor family
 - 3. User replaceable battery
 - 4. Communications capabilities
 - a. 1 Ethernet/IP port (provide interface module as required)
 - b. 1 RS232 serial port
 - 5. I/O Modules:
 - a. Current Inputs (4 to 20 mADC):
 - 1) Input Range: 0 to 20 mADC.

- 2) 8 differential inputs
- b. Current Outputs:
 - 1) Output Range: 0 to 20 mADC.
 - 2) 8 current outputs
- c. Discrete Digital Input Module
 - 1) 16 individually isolated inputs
- d. Discrete Digital Contact Output Module:
 - 1) Minimum of 8 normally open output relays, individually isolated

2.3 MEDIUM PROGRAMMABLE LOGIC CONTROLLER

- A. The PLC system should have as a minimum the following features and capabilities:
 - 1. Allen-Bradley CompactLogix, or SLC 5/05
 - 2. Highest user memory available for processor family
 - 3. User replaceable battery
 - 4. Communications capabilities
 - a. 1 Ethernet/IP port or 1 ControlNet port
 - b. 1 RS232 serial port
 - 5. I/O Modules:
 - a. Current Inputs (4 to 20 mADC):
 - 1) Input Range: 0 to 20 mADC.
 - 2) Minimum 8 differential inputs
 - b. Current Outputs:
 - 1) Output Range: 0 to 20 mADC.
 - 2) Minimum 8 current outputs
 - c. Discrete Digital Input Module
 - 1) 16 individually isolated inputs
 - d. Discrete Digital Contact Output Module:
 - 1) Minimum of 8 normally open output relays, individually isolated

2.4 LARGE PROGRAMMABLE LOGIC CONTROLLER

- A. The PLC system should have as a minimum the following features and capabilities:
 - 1. Allen-Bradley ControlLogix, or equal
 - 2. 16 MB of available user memory or higher
 - 4. 64 MB of nonvolatile memory
 - 5. Communications capabilities
 - a. 100 MB Ethernet
 - b. Onboard RS232 serial port
 - 6. I/O Modules:
 - a. Current Inputs:
 - 1) Allen-Bradley 1756-IF16, or equal
 - 2) Input Range: 0 to 20 mADC.
 - 3) 16 differential inputs
 - b. Current Outputs:
 - 1) 1756-OF8, by Allen-Bradley or equal
 - 2) Output Range: 0 to 20 mADC.

- 3) 8 current outputs
- c. Discrete Digital Input Module
 - 1) 1756- IA16I, by Allen-Bradley or equal
 - 2) 16 individually isolated inputs
- d. Discrete Digital Contact Output Module:
 - 1) 1756- OW16I, by Allen-Bradley or equal
 - 2) 100-240VAC output module

PART 3 - EXECUTION

3.1 ENVIRONMENTAL CONDITIONS

- A. The complete monitoring and control system and associated input/output wiring will be used in a water/wastewater treatment facility environment where there will be high energy AC fields, DC control pulses, and varying ground potentials between the transducers or input contact locations and the system components. The system design shall be adequate to provide proper protection against interferences from all such possible situations.
- B. The PLC components shall be designed and constructed for satisfactory operation and long, low maintenance service under the following environmental conditions:
 - 1. Temperature range: 32 to 122°F continuous.
 - 2. Relative humidity: 5 through 95 percent (non-condensing).
- C. The Control rooms will normally be air-conditioned to achieve environmental conditions outlined above. No positive control of relative humidity is provided or contemplated. However, in the event of a failure of the air conditioning system, the entire monitoring and control system shall be capable of operating continuously and satisfactorily with ambient temperatures between 32 and 104°F and with relative humidity to 95 percent (non-condensing).

++ END OF SECTION ++

SECTION 13452

SCADA SYSTEM
HUMAN MACHINE INTERFACE
HARDWARE AND SOFTWARE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide the services of the System Supplier as described in Section 13401, SCADA System, General Requirements, to load, configure, develop, test, document, and place in satisfactory operation all software associated with the SCADA System and all its ancillary devices, as described herein, required by other Sections, as shown and as required to provide a properly operating and integrated system.
2. The software and hardware required for the SCADA System is described in this specification and is comprised of the following types of major monitoring processing and control equipment units:

NTS: DESIGN PROFESSIONAL SHALL EDIT AND DELETE EQUIPMENT AS REQUIRED.

- a. HMI Software.
- b. HMI Hardware.

B. Related Sections:

1. Section 13401, SCADA System, General Requirements
2. Section 13451, SCADA System, Programmable Logic Controller Hardware and Software
3. Section 13460, SCADA System, Computers and Computer Networks
4. Section 13491, SCADA System, Control Descriptions

C. Terms:

1. HMI – Human Machine Interface
2. PLC – Programmable Logic Controller

NTS: DESIGN PROFESSIONAL SHALL EDIT AND DELETE THIS SECTION AS
REQUIRED.

1.2 SYSTEM CONFIGURATION

- A. The system configuration shall be as specified herein and as described in Section 13491, Control Descriptions. Some variations in the configuration will be considered provided functional constraints as intended for the various components of the system are met. Hardware requirements are specified in Section 13451, SCADA System, Programmable Logic Controller Hardware and Software and Section 13460, SCADA System Computers and Computer Networks. Software requirements for the HMI system and for interfacing with other microprocessor-based equipment are specified herein.
- B. The Contract Documents illustrate and describe the overall SCADA System functional and operational requirements. The System Supplier is responsible for tagging, integrating, and verifying the functionality of all system components.
- C. All process and monitoring software shall be designed, manufactured, and configured specifically for the demanding requirements of real-time process management and control on a continuous basis for use in a wastewater treatment system.

1.3 SCADA SYSTEM HARDWARE

- A. The SCADA system shall operate as one integrated system. All software and drivers will be required to integrate other microprocessor-based equipment into the SCADA system to form a fully integrated system shall be provided under this Section.

NTS: DESIGN PROFESSIONAL SHALL EDIT THE FOLLOWING SECTION TO
INCLUDE THE HARDWARE BEING PROVIDED WITH EACH PROJECT.

- B. The SCADA System hardware includes, but is not limited to, SCADA Workstations, Development Workstations, SCADA Servers, Historical Servers, and Operator Interface Terminals.
 - 1. The SCADA Workstations shall provide operator access to the system for monitoring and control purposes and access reporting programs. SCADA workstations shall be provided with all HMI system software necessary for operation of the system, trending and short-term data archiving. All systems shall be functionally similar as to display arrangements, menu selections, command terminology, and data access methods. All Workstations shall be capable of accessing typical operator process control functions. Each

SCADA Workstation's functional environment shall be password protected for system security and user identification.

2. The SCADA Servers shall function as the primary means of communication between the SCADA Workstations and field controllers. SCADA Servers shall be provided with all HMI system software and PLC drivers necessary for direct communication with system PLC's, VFD's, power monitoring hardware, and printers. The SCADA Servers shall house the HMI tag database and all SCADA Workstations shall update their displays from the tag databases on the HMI Servers. All systems shall be functionally similar as to display arrangements, menu selections, command terminology, and data access methods. The SCADA servers shall also function as print servers, allowing the printers to be accessed by any of the Servers or Workstations on the control network. The SCADA Servers shall be configured to continuously print logged alarms to their designated alarm printers for hardcopy backup. Each SCADA Server's functional environment shall be password protected for system security and user identification.
3. The Historical Servers shall function as the primary means of archiving process data within a SQL database. The Historical Servers shall be provided with all software necessary for direct communication with the SCADA servers to periodically poll the tag database and record process data for later viewing using reporting software on the SCADA Workstations. The Historical Servers shall house the SQL database and all SCADA Workstations shall update their reports from the SQL databases on the Historical Servers. All systems shall be functionally similar as to display arrangements, menu selections, command terminology, and data access methods. Each Historical Server's functional environment shall be password protected for system security and user identification.

NTS: DESIGN PROFESSIONAL SHALL MODIFY THIS SECTION FOR
REDUNDANCY SPECIFIC FOR EACH PROJECT.

C. System redundancy:

1. The SCADA system shall be furnished with two redundant SCADA Servers and one Historical Server or as shown on the Contract Drawings.
2. The system shall be configured so that both pairs of servers are online under normal conditions with one of the servers running as the primary server and the other server in standby mode. The SCADA Workstations shall automatically update their data from the primary server and, when necessary, automatically switch to the standby server in the event the primary server is not active.
3. In the event of a SCADA Server or Historical Server failure, the system shall automatically reconfigure itself so that all SCADA Workstations will update their data from the functional Server with no noticeable downtime.

4. The system shall be configured so that once the failed Server is repaired, all lost data may be automatically updated to it and the Server may be returned to service with no noticeable downtime.

D. Workstation / Server primary roles:

	SCADA WORKSTATION	OPERATOR INTERFACE	ENGINEER INTERFACE	SCADA SERVER	HISTORICAL SERVER
SCADA Screens	View	View	View, Configure	View, Configure	None
Historical Reports	View	None	View, Configure	None	View, Collect, Record, Configure
Historical Trends	View	View	View, Configure	None	View, Collect, Record, Configure
Communications	With SCADA Servers, Historical Servers, Printers	With SCADA Servers, Historical Servers, Printers	With SCADA Servers, Historical Servers, SCADA Workstations, Printers	With PLC's, VFD's, Power Monitors, Printers	With SCADA Servers, Printers
SCADA Database	None	None	View, Configure	View, Collect, Configure	None
Alarms	View	View	View, Configure	Collect, Record, Print, Dial	Collect, Record
PLC Code	None	None	View, Configure	None	None
Network Utilities	None	None	View, Configure	None	None
VFD Utilities	None	None	View, Configure	None	None

1.4 SYSTEM LICENSES

- A. The HMI software shall be provided with all necessary software licenses to allow operation of the system as specified and as supplied. Licenses shall cover all software; including, but not limited to, operating systems and networking software. Licenses shall be for an unlimited time for use on the hardware provided as part of the Contract or their successors. Licenses shall include upgrade to new versions of the software in the future. Licenses shall not be location specific within the SCADA system, but shall cover the use of the system by the Owner and Engineer for software development during construction.

1.5 SYSTEM CONFIGURATION

- A. The system configuration shall be as shown on the Drawings. CONTRACTOR shall provide all supporting SCADA equipment, as required.
- B. The Process and Instrumentation Diagrams (P&ID's) and the specifications of this Section and the other applicable Division 13 Sections illustrate and describe the overall SCADA functional and operational requirements.

PART 2 – PRODUCTS

2.1 HMI SYSTEM LEVEL SOFTWARE REQUIREMENTS

- A. Operating System Software:
 - 1. The Workstation and Server operating system software shall be as specified in Section 13460, SCADA System, Computers and Networks.

- B. HMI System Software:
 - 1. HMI software shall monitor network resources and maintain current and historical performance information and statistics on all networked devices such as Servers, Workstations, PLC’s, Remote I/O, Distributed I/O, Variable Frequency Drives, Power Monitoring hardware, Networking hardware, etc. Management displays shall identify system faults, permit escalation of station faults and attached devices, fail and restart stations and attach/detach devices.
 - 2. HMI system level software shall include real time calendar/time, file management and dynamic memory allocation, on-line, on-demand and automatic diagnostics, communication and system level access security and automatic startup, fail over and shutdown routines.
 - 3. Specifics for the system are provided as a guide; however, manufacturer’s standard packages that can accomplish all of the specified functions will be considered.
 - 4. All HMI system software shall be supplied on compact discs (CDs) or digital video discs (DVDs) and shall provide fast system start-up, simple installation, and ease of building tasks, control schemes, and displays. For added security, the system furnished shall include provisions for copying the contents of main memory to recordable backup media through the use of single system commands. The recordable backup media shall then serve as a backup for reloading the system if required. System software shall provide for convenient addition, modification and control and alarm strategies, or trend and report formats.

 NTS: DESIGN PROFESSIONAL SHALL CONSULT WITH THE COUNTY FOR THE CORRECT VERSION OF SOFTWARE PACKAGE TO BE INSERTED IN NO. 1.

- 5. HMI system software shall be (--1--), by (Wonderware) Invensys Incorporated.

 NTS: DESIGN PROFESSIONAL SHALL COORDINATE NETWORK SPEEDS WITH NETWORK HARDWARE.

C. HMI Communication Software:

1. Data communication subsystems shall be comprised of industrial grade redundant communication buses that provide high-speed data transmission between all networked devices such as Servers, Workstations, PLC's, Variable Frequency Drives, Power Monitoring hardware, Networking hardware, etc. Each communication network shall be designed around the International Standards Organization's Open System Interconnection (OSI) Model, IEEE 802 Industry Standards and support a hierarchical communications network. Full TCP/IP and UDP support shall be provided.
2. Full peer-to-peer communication between nodes shall be provided. Local area network access shall be allowed via any appropriate third party network interface connector.
3. Communications hardware shall be as specified in Section 13463, SCADA System, Computers and Networks.

D. HMI System Configuration Tools:

1. A fully integrated HMI programming software package shall be provided to create and maintain process graphic screens, report generators, and system-wide configurations. The software shall be designed to execute independently so multiple copies of each tool can be deployed simultaneously on separate hardware platforms.
2. The HMI configuration software shall use an intuitive, menu-driver environment and base package platform. These easy-to-use Graphical User Interface (GUI) packages shall perform configuration and maintenance operations. Each viewing node in an on-line system shall contain an up-to-date view of all data needed by that node to monitor and control system processes.
3. Security shall be an integral component of the configuration software package. The HMI software shall provide two levels of access: viewing of system data and editing of the system. The system shall include, but not be limited to, process screens, data tables, scripts, etc.

NTS: DESIGN PROFESSIONAL SHALL COORDINATE WITH REPORTING
PACKAGE BEING USED.

4. The HMI configuration software shall allow easy integration of third-party products by being OLE Process Control (OPC) compliant.
5. The HMI configuration software package shall consist of the following:
 - a. A database builder capable of developing a local database used to hold process data and objects.
 - b. An Object Builder utilizing user-friendly intuitive package.
 - c. A Graphics Builder for rapid creation and editing of high-resolution process graphics.
 - d. A Script Compiler used to create custom user defined process actions or utilities.

- e. An export utility allowing for import or export of data to other systems.
6. The HMI configuration software shall allow viewing the complete database record of the selected process objects as well as making adjustments to point attributes such as scan status, alarm limits, and value.
7. The HMI configuration software shall allow reviewing and adjusting object related information, such as points generated from a list with specific characteristics, status conditions, and qualities. Review types shall include; Value limits, Engineering range limits, Limit alarms, Value clamp limits, Sensor limits, Alarm check remove, Cutout from alarming, Value clamp off, Entered value, External calibration, Scan remove, Tagged out, Timed out, and Quality.
8. The HMI configuration software shall provide capabilities to define and maintain the data associated with all system device configurations, including controller parameters. The HMI configuration software shall not depend on availability of Project hardware, allowing the entire configuration to be defined before the final system is assembled.
9. The Graphics Builder shall enable users to create and edit full-color, high resolution system displays. It shall use standard “click and drag” features for drawing, moving, and sizing objects and access drawing attributes (such as color, line width, fill pattern and text size) from scrolling menus. Users shall be able to build interactive objects such as buttons, check boxes, choice items, event menus, and sliders. An extensive symbol editor shall provide the capabilities to create, define, and store a minimum of 256 custom shapes.
10. The Object Builder shall also include support for conditional code (IF and LOOP commands), definition and inclusion of mathematical calculations, and reuse of existing objects.
11. The Object Builder shall enable users to add, delete, or modify process objects. To prevent name duplication, the Object Builder shall perform an immediate HMI database consistency check of added points. It shall also check whether attribute values for field objects are the correct type and range as the user enters all required fields.
12. With the Object Builder, users shall be able to define I/O parameters associated with each process object and perform complex queries of the database regarding any data point. I/O parameters shall include I/O type, memory address, description, calibration information, and conversion coefficients.
13. The HMI architecture shall support on-line execution (changes are reflected immediately on the running system) or off-line (work in progress). Support of on-line and remote upgrades of the components shall include on-line changes to the licensing manager.
14. The Database Builder shall provide the basic mechanisms for inserting data, organizing data in a meaningful way, securing data from unauthorized access, and retrieving data.
15. Changes to the distributed databases shall be performed as objects are added or updated in the Master Database. Online edits shall not remove the HMI system from service.

- E. SCADA Workstation Software:
1. The SCADA Workstation shall provide a high-resolution window to the process for control graphics, diagnostics, trending, alarms and system status displays. Through the Workstation, the user shall have access to dynamic system points as well as historical data, general messages, standard function displays, event logging, and a sophisticated alarm management program. Standard SCADA Workstation features shall include:
 - a. Process Diagrams.
 - b. Alarm Management.
 - c. Historical Trend viewing.
 - d. Report viewing.
 - e. Object Information/Object Review.
 2. The HMI Graphics Display shall organize and display process information using high-resolution graphics and advanced display features such as windowing, zoom, and pan. The following additional features shall be included:
 - a. Ability to indicate equipment status indicated via dynamic use of color, shape, and size of diagram elements.
 - b. User-definable links and paging hierarchy to provide flexible navigation.
 - c. Point values within process diagrams to quickly display applications related to the point selected (e.g., trend, point information or other related diagrams).
 - d. A standard display symbol library to aid in the consistency of appearance and speed of implementation.
 - e. Point groups allow one diagram to apply to more than one subsystem or piece of equipment.
 3. All dynamic data shall be updated each second.
 4. The Alarm software module shall allow Operators to view and acknowledge alarms from a hierarchy of alarm displays. Alarm management shall facilitate the identification of system abnormalities. Alarm management shall provide the following alarm display functions:
 - a. An Alarm List to display all current alarm entries in chronological order. Changes in alarm status indicate an update in the entry. Specific alarm returns are also displayed, but only if specified during configuration.
 - b. An Alarm History List shall display the most recent 5,000 alarm occurrences in chronological order on the HMI displays.
 - c. An Unacknowledged Alarm List to display unacknowledged alarms in chronological order.
 - d. A Reset List that identifies all resettable alarms in the system and provides the Operator with a single window for managing return resets. Alarms, which have been reset, shall clear from Alarm List and Reset List displays.
 - e. Alarm Destination function to filter alarms by specific system area. The Operator may view alarms for a specific station or for the entire system.
 - f. An Alarm Priority function to distinguish the importance of alarms with process point priorities defined on a scale of one to ten, minimum.

- g. An Alarm Acknowledgment function to acknowledge an alarm to indicate Operator awareness of an alarm condition or confirmation of an action to follow.
 - h. The ability to reset an unacknowledged alarm in order to be removed from the Alarm List.
 - 5. The Trending Software shall display data samples, in graphic or tabular format, of live points collected from the network over a selected time interval. The Operator may view both real-time and historical trend displays. For quick access to information regarding a pre-defined set of points, Operators shall be able to build specific trend groups. The Trending Software shall support up to four simultaneous trend windows of up to eight points for each trend window. Each trend line shall support 600 sample data values, minimum. Other trend display features shall include:
 - a. Operator-selectable trend colors.
 - b. Horizontal, vertical, X-Y, and tabular formats.
 - c. Scrolling, hairline cursor feature to read actual trend values.
 - d. Baseline color feature for selection of color shading between actual values and set points.
 - e. Indication of points that are off-scan.
- F. Reporting Software:
 - 1. Reporting Software shall provide the framework for defining and generating system reports including:
 - a. Temporal Reports that are executed and scheduled in real time or periodic intervals.
 - b. Event Reports to summarize activity of user-defined data, which occurs during an event, triggered by one or more conditions.
 - c. Trip Reports to provide information prior to and following an equipment malfunction.
 - d. Operator Requested Reports to provide information based on an operator's request.
 - e. Calculated Reports to provide month-to-date information for processing data.
 - 2. Report Builder:
 - a. A Report Builder shall be provided on each Historical Server and on each Development Workstation to define the format of reports. Free formatting shall be provided using commercially available reporting software for flexibility when defining the layout of a report. Presentation of the reports shall be enhanced by the ability to choose several chart formats and by adding color to highlight information. Report templates and macros shall be available for frequently used formats.
 - b. The Report Builder shall allow the user to quickly review or recall a cell's definition and format. The Report Builder shall be able to replicate reporting styles for multiple processes that are identical. This shall enable the user to make changes to reporting style in one place.
 - 3. Report Generator:

- a. A Report Generator shall construct a report using a layout defined by the Report Builder and the appropriate system data. Report definitions shall include the report layout, data, and report trigger (request, event, or timer). Data shall be retrieved from the data logger as necessary. Report generation shall be able to be triggered by an operator request, an event, or a user-defined periodic timer. After report generation, output shall be sent to a report printer or saved as a file in either ASCII or commercial spreadsheet format.
4. Data Logging Software:
- a. Data logging software shall be provided on each Historical Server. The data logging software shall provide mass storage and retrieval of process data and alarms to be retrieved by the reporting software. Integrated tools shall provide viewing, sorting and data analysis without the need for additional software.
 - b. Scanning and Collecting: The data logger shall scan and collect the following types of historical data defined by user:
 - i. Real-Time Process Value History: The data logger shall monitor and store process point data at user defined intervals. Collection shall be for points defined by the user. The data logger shall also process individual user requests to retrieve process point information, providing data for operator trending functions. The software shall include the option to export all stored data to a flat file format, text delimited, web page, and a standard spread sheet.
 - ii. Aggregated Value History: The data logger shall collect, calculate and store aggregated value data at user defined intervals. Collection shall be for points defined by the user. Aggregated values shall include, but not be limited to; averages, maximums and minimums for all analog instrumentation; daily and lifetime totalizers for all flow instruments; and lifetime run time hours for all motorized equipment. The software shall include the option to export all stored data to a flat file format, text delimited, web page, and a standard spread sheet.
 - iii. Alarm History: The alarm historian shall receive and store all alarms. Once the alarms have been stored, the historian shall allow an Operator to display, print, or save to a file the list of alarms collected. It shall also provide the capability to filter the alarm list based on factors such as point name or time period. The software shall include the option to export all stored data to a flat file format, text delimited, web page, and a standard spread sheet.
- G. Historical Trend Data Logging Software:
- 1. Historical trend data logging software shall be provided on each Historical Server. The historical logging software shall provide mass storage and retrieval of process data to be retrieved by the HMI software's historical trending package. Integrated tools shall provide viewing, sorting and data analysis without the need for additional software.

2. The historical trend data logger shall scan and collect real-time process value history at user defined intervals. Collection shall be for points defined by the user. The historical logger shall also process individual user requests to retrieve process point information, providing data for operator trending functions.
3. The software shall include the option to export all stored data to a flat file format, text delimited, web page, and a standard spread sheet.
4. Historical trend data logs shall be stored in individual daily files containing data from one 24-hour period.
5. Historical trend data logs shall be stored for a minimum of 180 days.
6. Historical trend data logs shall be stored in a manner that they may be manually backed up to recordable media periodically and easily restored from backups. This backup and restore process shall not remove trend collection from service.

 NTS: DESIGN PROFESSIONAL SHALL VERIFY THE NEED FOR ALARM DIALING SOFTWARE FOR EACH PROJECT. VERIFY IF A MODEM IS SPECIFIED WITH THE COMPUTER HARDWARE. VERIFY IF AN ANALOG TELEPHONE LINE IS SPECIFIED. DEFINE WHICH MACHINE THE ALARM DIALING SOFTWARE WILL BE INSTALLED ON.

H. Alarm Dialing Software:

1. Alarm Dialing Software shall provide remote notification and acknowledgement of alarms generated from the HMI.
 - a. Software shall utilize a standard TAPI-compliant modem to dial preconfigured telephone numbers.
 - b. Software shall utilize text-to-speech technology to communicate alarm conditions to personnel when dialed.
 - c. Software shall include security features to authenticate users and filter access based on caller ID lists.
 - d. Standard alphanumeric and numeric messages to pagers and mobile telephones shall be supported.
 - e. Software shall also support email notification, including email reports when alarms are activated, acknowledged, and cleared. Software shall also support automatic email of alarm log files at preset intervals.

 NTS: DESIGN PROFESSIONAL SHALL VERIFY WITH THE COUNTY WHICH MANUFACTURER AND MODEL OF OPERATOR INTERFACE TERMINAL SHALL BE USED FOR EACH PROJECT. BASED ON THIS CHOICE, DESIGN PROFESSIONAL SHALL CHOOSE ONE CHOICE OF SECTIONS "B" AND EDIT SECTION "D" OF 2.2.

2.2 OPERATOR INTERFACE TERMINALS

A. General:

1. Operator Interface Terminals (OIT's) shall be utilized as the human-machine interface in the field as shown. All stations shall be functionally similar as to display arrangements, menu selections, command terminology, and data access methods.
2. All OIT's shall be functionally interchangeable differing only in the software installed on each type. All OIT's shall be capable of accessing typical operator process control functions. Each station's functional environment shall be password protected for system security and user identification. Required number of OIT's shall be provided as shown.
3. Provide all necessary interface hardware and protocol drivers for the supplied systems.
4. Provide an extended warranty for 36 months for parts and labor.

B. The Operator Interface Terminals shall be a flat panel, industrial hardened PC computer. They shall be rated NEMA 4X panel mountable, industrial PC Workstations designed for harsh environments, with sealed front panel displays and keyboards. The units shall be designed and approved for use in hazardous locations Class I, Division 2, Groups A, B, C and D; Class II, Division 2, Groups F and G. Each station shall be constructed of identical parts and components and shall be provided with the following minimum features and functions:

1. Display Description: Color Active Matrix TFT.
2. Display Size and Area: 10.4 inch and 8.3 inch by 6.2 inch.
3. Resolution: 1280 X 1024, 18-bit Color Graphics.
4. Real-time Clock: Battery-backed time clock timestamps critical data.
5. Application Software: FactoryTalk View Studio
6. Application Memory: 64 MB RAM/ 64 MB Flash, 25 MB for application storage.
7. Touch Screen: Analog resistive.
8. Keypad: Stainless steel domed membrane with 32 function keys.
9. Communication Ports: Ethernet, RS-232, 2 USB plus, optional DH+/DH - 485/Remote IO, ControlNet or DeviceNet Module.
10. Ratings: Nema type 12, 13, 4X, IP54, IP65.

B. The Operator Interface Terminals shall be a flat panel, industrial hardened PC computer. They shall be rated NEMA 4X panel mountable, industrial PC Workstations designed for harsh environments, with sealed front panel displays and keyboards. The units shall be designed and approved for use in hazardous locations Class I, Division 2, Groups A, B, C and D; Class II, Division 2, Groups F and G. Each station shall be constructed of identical parts and components and shall be provided with the following minimum features and functions:

1. Display Description: LCD 32-bit color display, with resistive touch screen with Intel Extreme Graphic with 64 MB shared video RAM.
2. Display Size and Area: 19 inch.
3. Resolution: 1024 X 768 pixel.

4. Real-time Clock: Battery-backed time clock timestamps critical data.
 5. Application Software: FactorySuite on Windows 2003 Pro Operating System.
 6. Application Memory: 64 MB RAM/ 64 MB Flash, 25 MB for application storage.
 7. Processor: Pentium 1.7 GHz with 2 GB RAM Memory.
 8. Keypad: Onscreen keyboard.
 9. Communication Ports: Two Ethernet 10/100T, Two RS-232, 2 USB plus, One RS422/485, Two PS/2 and One USB on front.
 10. Meantime between failures: 40,000 hours.
- C. The units shall be designed for and capable of functioning in the indicated modes, without external auxiliary equipment, with no detrimental effects under the following environmental conditions.
1. Temperature:
 - a. Operating: 0 to 50°C (32 to 122°F).
 - b. Non-operating: -20 to 60°C (4 to 140°F).
 2. Humidity:
 - a. Operating: 20 to 80 percent RH, non-condensing.
 - b. Non-operating: 20 to 80 percent RH, non-condensing.
 3. Altitude:
 - a. Operating: Sea level to 10,000 feet (3048 m).
 - b. Non-operating: Sea level to 40,000 feet (12,192 m).
 4. Electrical:
 - a. 90 to 240 VAC.
 - b. 47 to 63 Hz.
- D. Products and Manufacturers: Provide one of the following:
1. PanelView Plus 1000 by Allen Bradley.
 2. Wonderware Touch Panel by Invensys.
 3. Or equal.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. General:
1. Install all equipment and components in accordance as shown, with approved Shop Drawings and installation instructions furnished by the manufacturer.

++ END OF SECTION ++

SECTION 13460

SCADA SYSTEM
COMPUTERS AND COMPUTER NETWORKS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish, install, test, start up, and place in satisfactory operation complete Supervisory Control and Data Acquisition System (SCADA) computers and computer network. System shall be as specified in the applicable Specifications and as shown. System includes the following equipment:

NTS: INSERT AT NO. 1 A LIST OF MAJOR EQUIPMENT ITEMS COVERED IN THIS SECTION, SUCH AS: "Workstation computers", "Network server computer", "Historian computer", "Network switch", "Printers", AND OTHERS.

- a. (--1--).
2. SCADA computers and computer network shall allow computers to share data and use common equipment, such as printers and servers.
3. Coordinate with County's Information Technology Department (ITD) for all cable requirements for Data and Control Networks.
4. The configuration and addressing of all new network switches and routers shall be performed by the Pima County Information Technology Department (ITD) staff.

NTS: RETAIN PARAGRAPH "3" ONLY IF THE PROJECT IS A MULTI-DISCIPLINARY PROJECT WHERE CONTRACTOR MAY NOT BE THE SUPPLIER. WHEN THE CONTRACTOR IS THE SUPPLIER, REPLACE THE FIRST SENTENCE IN PARAGRAPH "3" WITH: "CONTRACTOR IS RESPONSIBLE FOR THE WORK SPECIFIED IN THIS SECTION."

6. Retain Supplier of SCADA computers and computer network for responsibilities specified below. Work by Supplier shall not relieve CONTRACTOR of responsibility for the SCADA computers and computer network.
 - a. Designing, fabricating, and implementing of SCADA computers and computer network and all subsystems in accordance with the Contract Documents.
 - b. Preparing, assembling, and correcting all SCADA computers and computer network submittals in accordance with the Contract Documents.
 - c. Proper interfacing of SCADA computers and computer network hardware and software.
 - d. Supervising installation of SCADA computers and computer network.
 - e. Testing and start-up of SCADA computers and computer network.
 - f. Training of OWNER's personnel in operating and maintaining SCADA computers and computer network.
 - g. All warranty obligations for computers and network components.
 - h. Maintaining two reproducible copies of complete system and running software at Supplier's facility throughout the correction period.

B. Related Sections:

1. Section 13401, SCADA System General Requirements
2. Section 13402, SCADA System Factory Testing.
3. Section 13403, SCADA System Start-up and Field Testing.
4. Section 13430, SCADA System, Panels and Enclosures

 NTS: DESIGN PROFESSIONAL SHALL VERIFY THE EXACT VERSION OF THE TELECOMMUNICATION DESIGN STANDARDS AND INSERT AT NO. 1.

1.2 QUALITY ASSURANCE

- A. Comply with the requirements of Section 13401, SCADA System, General Requirements.
- B. All cabinets and panels for the Computers and Networks equipment shall be constructed per the County's Information Technology Department's Design Standards, Version (--1--).

1.3 SUBMITTALS

- A. General:
 1. Start preparing Shop Drawings and related submittals only after pre-submittal conference specified in Section 13401, SCADA System, General Requirements.

2. SCADA computers and computer network materials and equipment shall not be manufactured until related submittals have been approved or accepted by ENGINEER.
3. Shop Drawings and submittals shall be furnished in complete packages grouped to permit review of related items.

 NTS: DESIGN PROFESSIONAL SHALL COORDINATE WITH THE COUNTY SCADA GROUP TO FACILITATE COORDINATION WITH THE COUNTY'S IT DEPARTMENT REGARDING COORDINATION OF LATEST COUNTY STANDARDS FOR COMPUTERS AND COMPUTER NETWORK EQUIPMENT.

B. Action Submittals: Submit the following:

1. Shop Drawings:
 - a. Drawings of proposed layout of computer network and communications, showing computers and related equipment in relation to each other.
2. Product Data:
 - a. Manufacturer literature containing product name and model number.
 - b. Manufacturer standard catalog data for materials and equipment proposed.
 - c. Description of construction features.
 - d. Dimensions and weights.

C. Informational Submittals: Submit the following:

1. Supplier shall coordinate with the County's Information Technology Department for the latest standards for computer and network equipment.
2. Reports:
 - a. Two copies of the following reports shall be submitted to ENGINEER:
 - 1) Factory Test Reports if specified in Section 13402, SCADA System Factory Testing.
 - 2) Installation Inspection, and Field Testing Reports as specified in Section 13403, SCADA System Start-Up and Field Testing.
3. Manufacturer's Instructions:
 - a. Installation and mounting details, instructions, and recommendations.
 - b. Service requirements.

 NTS: DESIGN PROFESSIONAL SHALL INSERT THE CORRECT SPECIFICATION NUMBER AT NO. 1.

D. Closeout Submittals: Submit the following:

1. Operations and Maintenance Data: Furnish operation and maintenance manuals for SCADA computers and computer network in accordance with Section (--1--

), Operation and Maintenance Data. Operation and maintenance manuals shall include:

- a. Complete list of supplied hardware parts with model numbers referenced to system part designations, including spare parts and test equipment furnished.
- b. Copy of all approved and accepted submittals specified in this Section with revisions made to reflect actual system as tested and installed. Include half-size black-line copies of Shop Drawings originally on paper larger than 11 inches by 17 inches.
- c. Complete, up-to-date documentation for vendor supplied application software.
- d. Manufacturer originals of hardware, software, installation, assembly and operations manuals, including:
 - 1) General descriptive information covering basic features of materials and equipment furnished.
 - 2) Description of layout and installation requirements and all environmental constraints.
 - 3) Maintenance procedures covering checkout, troubleshooting, and servicing. Checkout procedures shall provide means to verify satisfactory operation of materials and equipment. Troubleshooting procedures shall serve as guide in determining faulty components. Servicing procedure shall cover requirements and recommended time schedule for Supplier's recommended preventive maintenance.
 - 4) Wiring and schematic diagrams.
 - 5) Safety procedures and recommendations for operation and maintenance.

NTS: DESIGN PROFESSIONAL SHALL INSERT THE CORRECT SPECIFICATION NUMBERS AT NO. 1 THROUGH 4.

- 2. Record Documentation: Comply with Section (--1--), Record Documents, and the following:
 - a. Revise all Shop Drawings, submittals, and software documentation to reflect installed conditions.
 - b. Submit to ENGINEER the same number of revised submittals and documentation as operations and maintenance manuals required in Section (--1--), Operations and Maintenance Data. Updated submittals and documents will replace outdated copies of submittals and documentation in the System Operation and Maintenance Manuals. Furnish half-size black-line drawings for all drawings larger than 11 inches by 17 inches.
 - c. Provide with record drawings submittal specific instructions regarding replacement of outdated documents.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packing, Shipping, Handling, and Unloading

1. Make all arrangements for transporting, delivering, and storing materials equipment in accordance with Section (--3--), Transportation and Handling of Products, and requirements of the Supplier.
2. SCADA computers and computer network equipment shall be packaged at factory prior to shipment for protection during shipment and storage. Containers shall be protected against impact, abrasion, corrosion, discoloration, and other damage. Clearly label contents of each container and information on storage conditions required.
3. Inspect all boxes, crates, and packages upon delivery to Site and notify ENGINEER in writing of loss or damage to materials and equipment. Promptly remedy loss and damage to new condition in accordance with Supplier’s instructions.

B. Storage and Protection:

1. Store SCADA computers and computer network equipment in accordance with Section (--4--), Storage and Protection of Products, and Supplier instructions. Prior to shipping materials and equipment from factory, Supplier shall notify CONTRACTOR in writing of storage requirements and recommendations.

PART 2 - PRODUCTS

2.1 SYSTEM PERFORMANCE

 NTS: FOR MODIFICATION/REHAB PROJECTS, VERIFY THAT CONDITIONED POWER SOURCE OR UPS EXISTS AND IS BEING UTILIZED BY THE SCADA COMPUTERS AND COMPUTER NETWORK COMPONENTS BEING REPLACED BEFORE RETAINING PARAGRAPH “A.1”. IF CONDITIONED POWER SOURCE EXISTS, DELETE PARAGRAPH “A.1”.

A. General:

1. All SCADA computers and computer network components shall be powered from conditioned power source or uninterruptible power supply (UPS) that shall provide reliable source of uninterruptible power during complete or partial interruption of incoming line power.
2. Tag all components with item number and nomenclature indicated on the Contract Documents.

B. Power Supplies:

1. All electrically-powered equipment and devices shall be suitable for operation on 115 volt ±10 percent, 60 Hertz ± 2 Hz power. If different voltage or closer regulation is required, provide suitable regulator or transformer.

2. Power supplies shall be suitable for minimum of 130 percent of maximum simultaneous current draw.

C. Environmental Conditions:

1. Design and construct SCADA computers and computer network for continuous operation under the following conditions:
 - a. Control Rooms:
 - 1) Ambient Temperature: 60 degrees F to 90 degrees F normal range; 40 degrees F to 105 degrees F occasional maximum extremes.
 - 2) Relative Humidity: 80 percent normal; 95 percent maximum.
 - b. Products located indoors but outside of control rooms:
 - 1) Ambient Temperature: 40 degrees F to 120 degrees F.
 - 2) Relative Humidity: 98 percent maximum.
 - c. Each panel for the computers and network equipment shall be provided with temperature readings to be monitored at the SCADA system.

NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY REGARDING
THE MINIMUM REQUIREMENTS FOR THE FOLLOWING EQUIPMENT.

2.2 SCADA WORKSTATION

A. General:

1. SCADA Workstations shall be utilized as the human-machine interface as shown.
2. All SCADA Workstations shall be functionally interchangeable differing only in the network address. Each Workstation's functional environment shall be password protected for system security and user identification. Required number of SCADA Workstations shall be provided as shown.
3. Each SCADA Workstation shall include a high-resolution flat panel LCD display designed for continuous operation and use in conjunction with the Workstation modules.
4. Local controls shall be provided with each LCD monitor for contrast, brightness, tint, and focus. Radiation emission shall comply with existing industry standard requirements. The monitor shall have tilt and swivel base.
5. The keyboard shall be laid out for ease of operation and shall contain 101 English language keys for entering alphabetic, numerical, and functions for display and control purposes. Functionally it shall emulate a standard IBM PC keyboard and consist of the full set of alphanumeric keys plus punctuation and special symbol keys laid out in standard QWERTY format, a numeric data entry panel with cursor control. Cursor control shall permit fast, efficient movement of the cursor for positioning on screen: up, down, right, left, and home key shall be provided as a minimum. Cursor control shall incorporate the use of a mouse interface, which converts its physical movement in data signals. The signals shall be interpreted by software which causes an icon on the LCD display to

mirror the mouse's movement; two buttons on the mouse shall allow the operator to make selections on areas of the screen determined by the position of the icon.

6. Provide equipment to operate on 115 VAC, single phase, 60-hertz electrical service.
7. Provide all necessary items for installation, including mounting brackets, interconnecting cables, hardware and appurtenances.

B. SCADA Workstation Hardware:

1. Each SCADA Workstation shall consist of individual Workstation electronics (e.g., Workstation electronics shall NOT be shared amongst more than one Display Workstation) to support one high resolution flat panel LCD display, data highway communications and utilize a password-protected resource configuration environment for high level system and control configuration.
2. Processor: Intel® Xeon® Processor 5110, 1.6 GHz, 2x2MB Cache, 800MHz FSB, minimum.
3. Memory: 2 GB, DDR2 SDRAM FBD memory, minimum.
4. Monitor: 19-inch color flat panel display with VGA/DVI inputs and integrated stereo speakers.
5. Graphics: 256MB dedicated video memory, minimum. DVI & VGA outputs.
6. Hard Drive: 160 GB minimum SATA, 7200 rpm.
7. Floppy Drive: 3.5-Inch, 1.44 MB Diskette.
8. Optical Drive: 16X DVD+/-RW and 48XCDRW minimum.
9. Mouse: Standard 2-button optical with scroll wheel, with USB as a minimum.
10. Network Interface Card: Integrated Broadcom Gigabit Ethernet LAN 10/100/1000.
11. Keyboard: USB Entry Quietkey, Standard 104+ as a minimum.
12. Form Factor: Tower Case.
13. Documentation: Provide all documentation, manuals and licenses.
14. Environmental: Control room environment. (Refer to Division 1, General Requirements, for environmental requirements).
15. Safety/Regulatory: UL, FCC B, approved.

C. SCADA Workstation Software:

1. Microsoft Windows XP Professional, including latest Service Packs.
2. Microsoft Office Basic, latest version and service packs.
3. Anti-Virus Software from Sophus with minimum 1-year subscription.

NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY REGARDING
THE PREFERRED MODELS OF WORKSTATIONS TO BE INSERTED AT NO. 1.

D. Manufacturers:

1. (--1--) as manufactured by Dell.
2. Or equal.

2.3 DEVELOPMENT WORKSTATION

A. General:

1. The Development Workstation shall be utilized as the PLC and HMI programming device as shown.
2. The Development Workstation shall be a laptop form-factor computer including an integrated high-resolution flat panel LCD display designed for continuous operation.
3. LCD radiation emission shall comply with existing industry standard requirements.
4. The integrated keyboard shall be laid out for ease of operation and shall contain 101 English language keys for entering alphabetic, numerical, and functions for display and control purposes. Functionally it shall emulate a standard IBM PC keyboard and consist of the full set of alphanumeric keys plus punctuation and special symbol keys laid out in standard QWERTY format. Cursor control shall permit fast, efficient movement of the cursor for positioning on screen: up, down, right, left, and home key shall be provided as a minimum. Cursor control shall incorporate the use of a touchpad interface, which converts its physical movement in data signals. The signals shall be interpreted by software which causes an icon on the LCD display to mirror the touchpad movement; two buttons on the touchpad shall allow the operator to make selections on areas of the screen determined by the position of the icon.
5. Provide equipment to operate on 115 VAC, single phase, 60-hertz electrical service.
6. Provide all necessary items for installation, including interconnecting cables, hardware and appurtenances.

B. Development Workstation Hardware:

1. The Development Workstation shall consist of individual Workstation electronics (e.g., Workstation electronics shall NOT be shared amongst more than one Display Workstation) to support data highway communications and utilize a password-protected resource configuration environment for high level system and control configuration.
2. Processor: Intel Core 2 Duo Processor, 1.6 GHz, 2MB Cache, 667MHz FSB, minimum.
3. Memory: 1 GB DDR2 SDRAM, minimum.
4. LCD Panel: 17-inch wide format WXGA color flat panel display.
5. Graphics: 256MB dedicated memory, minimum.
6. Hard Drive: 80 GB minimum.
7. Floppy Drive: External USB 3.5-Inch, 1.44 MB Diskette.
8. Optical Drive: 8X DVD+/-RW, minimum.
9. Mouse: Integrated, with additional standard 2-button optical with scroll wheel.
10. Network Interface Card: Integrated Ethernet LAN 10/100.
11. Wireless Network Interface: Integrated 802.11g.
12. Keyboard: Integrated, with additional standard 104+.

13. Form Factor: Portable laptop.
14. Carrying case: Nylon, sized to adequately and safely store laptop for general use.
15. Documentation: Provide all documentation, manuals and licenses.
16. Environmental: Control room environment. (Refer to Division 1, General Requirements, for environmental requirements).
17. Safety/Regulatory: UL, FCC B, approved.
18. Port replication docking station.

C. Development Workstation Software:

1. Microsoft Windows XP Professional, including latest Service Packs.
2. Microsoft Office Basic, latest version and service packs.
3. Anti-Virus Software from Sophus with minimum 1-year subscription.

 NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY REGARDING
 THE PREFERRED MODELS OF WORKSTATIONS TO BE INSERTED AT NO. 1.

D. Products and Manufacturers:

1. (--1--) as manufactured by Dell.
2. Or equal.

2.4 SCADA SERVER

A. General:

1. SCADA Servers shall be utilized as the primary means of communication between the SCADA Workstations and field controllers as shown.
2. All SCADA Servers shall be functionally interchangeable differing only in the network address. Each Server's functional environment shall be password protected for system security and user identification. Required number of SCADA Servers shall be provided as shown.
3. Provide equipment to operate on 115 VAC, single phase, 60-hertz electrical service.
4. Provide all necessary items for installation, including mounting brackets, interconnecting cables, hardware and appurtenances.

B. SCADA Server Hardware:

1. Form Factor: 19" Rack Mount blade-style configuration with all hardware and cables necessary for the unit to be mounted.
2. Processor: 2 Dual Core Intel Xeon, 2.0 GHz, 4MB Cache, 1.6 GHZ, 1066 MHz FSB, minimum, each.
3. Memory: 8GB 667MHz DDR2 SDRAM, minimum.
4. Hard Drives: 2x 73GB minimum SAS 10K RPM hard drives, configured with SAS-SATA.
5. Network Interface Card: Integrated Dual Gigabit Ethernet LAN 10/100/1000.

6. Documentation: Provide all documentation, manuals and licenses.
7. Environmental: Coordinate control room environment with Contract Drawings and Section 13430, SCADA Control Panels and Enclosures.
8. Furnish one external USB 24X CD/DVD+RW drive, minimum with each server.
9. Furnish one external USB 1.44MB 3 1/2" floppy drive with each server.
10. Safety/Regulatory: UL, FCC B, approved.
11. Furnish with an internal audio card.

 NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY REGARDING
 THE CORRECT VERSION OF WINDOWS TO BE INSTALLED ON THE SERVER.

C. SCADA Server Software:

1. Microsoft Windows (--1--) x32 Edition with Media Kit, including latest Service Packs and 5 CAL's.
2. Anti-Virus Software from Sophus with minimum 1-year subscription.
3. Server software shall be configured into existing SCADA domain with the guidance of the County's IT Department.

 NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY REGARDING
 THE PREFERRED MODELS OF SERVERS TO BE INSERTED AT NO. 1.

D. Products and Manufacturers:

1. (--1--) as manufactured by Dell.
2. Or equal.

2.5 HISTORICAL SERVER

A. General:

1. Historical Servers shall be utilized for archiving of process data within a SQL database as shown.
2. All Historical Servers shall be functionally interchangeable differing only in the network address. Each Server's functional environment shall be password protected for system security and user identification. Required number of Historical Servers shall be provided as shown.
3. Provide equipment to operate on 115 VAC, single phase, 60-hertz electrical service.
4. Provide all necessary items for installation, including mounting brackets, interconnecting cables, hardware and appurtenances.

NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY REGARDING DISK SPACE AND BACK-UP CAPABILITIES.

B. Historical Server Hardware:

1. Form Factor: 19" Rack Mount blade-style configuration with all hardware and cables necessary for the unit to be mounted.
2. Processor: 2 Dual Core Intel Xeon, 2.0 GHz, 4MB Cache, 1333MHz FSB, minimum, each.
3. Memory: 8GB 667MHz DDR2 SDRAM, minimum.
4. 2x 73GB minimum SAS 10K RPM hard drives, configured with SAS-SATA.
5. Network Interface Card: Integrated Dual Gigabit Ethernet LAN 10/100/1000.
6. Documentation: Provide all documentation, manuals and licenses.
7. Environmental: Control room environment. (Refer to Division 1, General Requirements, for environmental requirements).
8. Furnish one USB I/O dongle with each server for connection to removable media devices.
9. Furnish one external USB 24X CD/DVD+RW drive, minimum with each server.
10. Furnish one external USB 1.44MB 3 1/2" floppy drive with each server.
11. Safety/Regulatory: UL, FCC B, approved.

NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY REGARDING THE CORRECT VERSION OF WINDOWS TO BE INSTALLED ON THE SERVER.

C. Historical Server Software:

1. Microsoft Windows (--1--) x32 Edition with Media Kit, including latest Service Packs and 5 CAL's.
2. Microsoft Office Basic, latest version and service packs.

NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY REGARDING THE PREFERRED MODELS OF SERVERS TO BE INSERTED AT NO. 1.

D. Products and Manufacturers:

1. (--1--) as manufactured by Dell.
2. Or equal.

2.6 BLACK & WHITE LASER PRINTER

A. General:

1. Provide equipment to operate on 115 VAC, single phase, 60-hertz electrical service.

2. Provide all necessary items for installation, including mounting brackets, interconnecting cables, hardware and appurtenances.

B. Black & White Laser Printer:

1. Print Speed: 45 pages per minute, minimum.
2. Print Modes: Portrait and landscape.
3. Character Set: 94 ASCII characters.
4. Print Resolution: 1200x1200 dots per inch.
5. Memory: 64 MB, minimum.
6. Print Language: Enhanced HP PCL6 and Adobe postscript level 3.
7. Paper Trays: Two minimum, 500 total sheets minimum.
8. Paper: Plain paper sizes; 8.5 by 11 inches.
9. Monthly Rated Volume: 10,000 pages, minimum.
10. Mounting: Desktop.
11. Quantity: As shown.
12. Provide a printer which is “network ready”, with a pre-installed internal network interface card to allow easy connection to an Ethernet-based local area network. Include any required related network printer management utilities.
13. The network interface software supplied must be compatible with the operating system which is used for the PCS operator workstations.
14. Provide cables and any other required devices to connect the printer to an Ethernet-based local area network.

 NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY REGARDING
 THE PREFERRED MODEL OF PRINTER TO BE INSERTED AT NO. 1.

C. Products and Manufacturers:

1. LaserJet (--1--), as manufactured by Hewlett-Packard.
2. Or equal.

2.7 COLOR LASER PRINTER

A. General:

1. Provide equipment to operate on 115 VAC, single phase, 60-hertz electrical service.
2. Provide all necessary items for installation, including mounting brackets, interconnecting cables, hardware and appurtenances.

B. Color Printer:

1. Self-contained unit to generate color graphic and text prints.
2. Print Speed (Normal mode): 22 pages per minute (black text); 22 pages per minute (color).
3. Print Modes: Portrait and landscape.

4. Print Resolution: 600x600 dots per inch (black text), 600x600 dots per inch (color).
5. Memory: 160 MB, minimum.
6. Print Language: Enhanced HP PCL6 and Adobe postscript level 3.
7. Paper Trays: Two minimum, 300 total sheets minimum.
8. Paper: Plain paper, 8.5 by 11 inches.
9. Mounting: Desktop.
10. Quantity: As shown.
11. Provide a printer which is “network ready”, with a pre-installed internal network interface card to allow easy connection to an Ethernet-based local area network. Include any required related network printer management utilities.
12. The network interface software supplied must be compatible with the operating system which is used for the PCS operator workstations. Provide any additional hardware and software necessary to allow color graphic printouts from the PCS operator workstations.
13. Provide cables and any other required devices to connect the printer to an Ethernet-based local area network.

 NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY REGARDING
 THE PREFERRED MODEL OF PRINTER TO BE INSERTED AT NO. 1.

C. Products and Manufacturers:

1. Color LaserJet (--1--), as manufactured by Hewlett-Packard.
2. Or equal.

2.8 ALARM PRINTER

A. General:

1. Provide equipment to operate on 115 VAC, single phase, 60-hertz electrical service.
2. Provide all necessary items for installation, including mounting brackets, interconnecting cables, hardware and appurtenances.

B. Alarm Printer:

1. Self-contained unit to generate continuous alarm printout.
2. Printing: 9-pin serial impact dot matrix.
3. Print Speed (Normal mode): 100 CPS, minimum.
4. Feed Method: Push/pull tractor, friction.
5. Column Width: 10, 12, 15, 20 CPI.
6. Memory: 128KB input buffer, minimum.
7. Noise Level: 55 dBA, maximum.
8. Paper: Continuous paper, 8.5 by 11 inches.
9. Mounting: Desktop.
10. Quantity: As shown.

11. Provide a printer which is “network ready”, with a pre-installed internal network interface card to allow easy connection to an Ethernet-based local area network. Include any required related network printer management utilities.
12. The network interface software supplied must be compatible with the operating system which is used for the PCS operator workstations.
13. Provide cables and any other required devices to connect the printer to an Ethernet-based local area network.

C. Printer Stand:

1. Provide freestanding, wheeled, printer stand designed for use with tractor-feed style printer. Unit shall have dual shelves or baskets for supply and receiving paper storage.
2. JPM-1, as manufactured by Just Pure Magic; or equal.

 NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY REGARDING
 THE PREFERRED MODEL OF PRINTER TO BE INSERTED AT NO. 1.

D. Products and Manufacturers:

1. Model (--1--), as manufactured by Epson.
2. Or equal.

2.9 ETHERNET LAYER 2 AND 3 SWITCHES AND ROUTERS

A. General:

1. Provide equipment to operate on 115 VAC, single phase, 60-hertz electrical service.
2. Provide all necessary items for 19” rack installation, including mounting brackets, interconnecting cables, hardware and appurtenances.
3. Configuration of the switches and routers provided by the CONTRACTOR will be performed by the County.

 NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY REGARDING
 THE MINIMUM REQUIREMENTS AND MODELS OF THE REQUIRED SWITCHES
 AT NO. 1 AND 2.

B. Ethernet Switch:

1. (--1--).

C. Products and Manufacturers:

1. Model (--2--), as manufactured by Cisco.
2. Or equal.

NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY REGARDING
THE CONTENT AND QUANTITY OF SPARE PARTS NEEDED WITH EACH
PROJECT.

2.10 TOOLS AND SPARE PARTS

- A. Provide the following spare parts:
 - 1. (--1--).
- B. Provide special tools and software necessary for normal operation, maintenance and diagnostic aids / repairs.
- C. Spare parts shall be packed in sturdy containers with clear indelible identification markings and shall be stored in a dry, warm location until transferred to the OWNER at the conclusion of the Project.

NTS: DESIGN PROFESSIONAL TO COORDINATE WITH COUNTY TO INSERT THE
CORRECT TITLE OF THE ROLE PLAYED BY ROGER RIKKOLA AS OF MAY 2008
AT NO. 1.

2.11 SOFTWARE LICENSES

- A. The software shall be provided with all necessary software licenses to allow operation of the system as specified and as supplied. Licenses shall cover all software; including, but not limited to, operating systems and networking software. Licenses shall be for an unlimited time for use on the hardware provided as part of the Contract or their successors. Licenses shall allow upgrade to new versions of the software in the future. Licenses shall not be location specific within the SCADA system, but shall cover the use of the system by the OWNER and ENGINEER for software development during construction.
- B. All software licenses should be provided to the (--1--) of the County.

PART 3 - EXECUTION (NOT USED)

++ END OF SECTION ++

SECTION 13480

SCADA SYSTEM
INPUT / OUTPUT LIST

PART 1 - GENERAL

A. SCOPE:

NTS: INSERT AT NO. 1 THE LIST OF PANELS. LIST BY EITHER AREA OR PLC
PANEL.

1. I/O lists are compiled for the following devices, each of which is listed separately:
 - a. (--1--).

- B. I/O lists are compiled in order by terminal block number, from top to bottom, as shown on the Drawings. The I/O lists for the existing PLC Panels list only the new I/O added under this Contract.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

++ END OF SECTION ++

NTS: LISTED BELOW ARE THE DESCRIPTIONS FOR EACH COLUMN HEADING
FOUND IN THE I/O LIST:

FACILITY THE ABBREVIATED NAME OF THE FACILITY. THIS IS ONLY
USED TO IDENTIFY TAGS TO THE HMI.

DESCRIPTION A DESCRIPTION OF EACH I/O POINT

I/O TYPE CHOICE OF ANALOG INPUT (AI), ANALOG OUTPUT (AO),
DIGITAL INPUT (DI), DIGITAL OUTPUT (DO).

LOW (0%) THE 0% ENGINEERING UNIT VALUE FOR AN ANALOG SIGNAL; 0 OR 1 FOR A DISCRETE SIGNAL DENOTING POLARITY (STANDARD FOR A DI WOULD BE 0).

HIGH (100%) THE 100% OR FULL SPAN ENGINEERING UNIT VALUE FOR AN ANALOG SIGNAL; 0 OR 1 FOR A DISCRETE SIGNAL DENOTING POLARITY (STANDARD FOR A DI WOULD BE 1).

ENG UNITS E.G.: GPM, FT., MGD, SCFM, PSI, DEG F, A, V, W, VA.

PLC NO. PLC REFERENCE NUMBER (USUALLY 2 CHARACTERS).

BLDG NO. BUILDING REFERENCE NUMBER (USUALLY 2 CHARACTERS).

LOOP SEQ NO. A TWO-CHARACTER NUMBER DEFINING THE LOOP NUMBER.

EQUIP NO. A TWO-CHARACTER NUMBER DEFINING THE DEVICE NUMBER.

ISA ID THE THREE-CHARACTER ISA IDENTIFIER.

TAG SUFFIX THE IS A TAG SUFFIX IF THE SIGNAL IS A DIGITAL SIGNAL (OR ANALOG SIGNAL IF THE LOOP NUMBER DOES NOT CHANGE IN A PARTICULAR UNIT).

TAG NAME DOES NOT HAVE TO BE ENTERED BY THE DESIGN PROFESSIONAL. THE "CONCATENATE" FUNCTION IN EXCEL WILL CREATE EACH TAG NAME.

I/O NAME: THIS COLUMN IS FOR THE POINT ADDRESS IN THE PLC DATABASE. THIS AND THE SUBSEQUENT COLUMNS CAN BE HIDDEN FOR THE CONTRACT DOCUMENTS AND BE FILLED OUT WITH THE RECORD DRAWINGS.

CHASSIS SLOT SLOT THE IO POINT IS TERMINATED.

POINT TYPE ENTER IF THE POINT IS A DATA POINT OR 16 BIT POINT ETC.

COMMENTS RESERVED FOR ALARM SETPOINTS, I/O DELETE-REPLACE OR OTHER SPECIAL INSTRUCTION.

SECTION 13491

SCADA SYSTEM
CONTROL DESCRIPTIONS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Scope:
 - 1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to configure the SCADA System to accomplish the functionality specified herein.

- B. This Section describes all of the anticipated control programming under this Contract. The control strategies are generally divided by the responsible supplier and further subdivided by panel.

- C. The required control strategies for the various unit operations is a combination of the representation shown on the Drawings and the requirements specified herein. The Drawings do not show all the required internal diagnostic indications. In addition to the signals shown on the Drawings, the following process control descriptions shall be provided, as a minimum:
 - 1. Signals of bad quality on any hard wired input/output point (such as zero milliamps on a 4 to 20 mADC circuit).
 - 2. Indication of a communications failure between any of the PLC's with the SCADA Servers. The broken communications link must be identified individually to assist in troubleshooting.
 - 3. Indication of a power failure at any of the PLC's and/or panels provided under Division 13. The power failure must be identified individually to assist in troubleshooting.
 - 4. Mismatch alarms for all motorized equipment (e.g., pumps and gates, etc.). If the status feedback does not agree with the command after a time delay, annunciate the alarm.
 - 5. Runtimes shall be provided for all major pieces of equipment.
 - 6. Verification of digital outputs to determine if the equipment has responded to the digital commands before proceeding to the next step in automatic operation.

- D. The process control descriptions are written descriptions of the basic configuration and/or programming required to implement the sequential control of the unit processes shown on the Drawings and as specified. The control

descriptions do not, in all cases, describe the process characteristics fully. Finalizing and tuning of strategies, as required, by the process characteristics shall be accomplished during start-up.

- E. The SCADA System shall be structured to implementation of all control strategy requirements. In addition, each control function shall be designed so that bumpless, balance free transfers are obtained during mode changeover and initialization. Where applicable, user-changeable parameters shall be automatically defaulted to a preset value if a specific value is not provided during system generation.

NTS: DESIGN PROFESSIONAL SHALL EDIT THE SECTION "F" BASED ON THE METHOD OF DELIVERY OF THE PROJECT. THIS SECTION WAS WRITTEN FOR A PROJECT WHERE AN INDEPENDENT COUNTY APPOINTED CONTRACTOR WILL BE PERFORMING THE CONFIGURATION WORK.

- F. The CONTRACTOR shall be responsible for delivering a complete set of Contract Documents to the COUNTY approved Consultant who will be performing the SCADA System programming and configuration for the project. The Contract Documents will include at a minimum the P&I Drawings, the Control Descriptions and the IO lists.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 (INSERT PROCESS AREA/FACILITY)

NTS: DESIGN PROFESSIONAL SHALL INSERT AT NO. 1 TO NO. 2 THE REQUIRED INFORMATION. EACH INDIVIDUAL PROCESS AREA/FACILITY SHALL HAVE AN INDIVIDUAL ARTICLE NUMBER. IF A FACILITY DOES NOT HAVE ANY DATA FOR ANY SECTION OF PARAGRAPH "C" (MONITORING AND CONTROL), THAT SECTION SHOULD BE MAINTAINED WITH "NOT APPLICABLE" TYPED WITHIN IT.

- A. General:
 - 1. Process and Instrumentation Diagrams: (--1--).
 - 2. Loop Numbers: (--2--).

NTS: INSERT AT NO. 3 GENERAL BACKGROUND OF THE FACILITY, WHICH WOULD INCLUDE THE FOLLOWING: LOCATION AND PURPOSE OF THE FACILITY, INTENDED OPERATIONS OF THE SYSTEMS AND ALL SYSTEMS AS A WHOLE, FLOW AND PROCESS INFORMATION THROUGH THE FACILITY AND A SHORT DESCRIPTION OF THE MAIN EQUIPMENT AND APPARATUS WITHIN THE PROCESS AREA.

- B. Overview:
 - 1. (--3--).

NTS: PROVIDE A BASIC DESCRIPTION OF THE CONTROL PHILOSOPHY OF THE FACILITY AND EQUIPMENT. COMPLETE THE TABLE BELOW, AS REQUIRED.

- C. Monitoring and Control:

Equipment	Local Panel Location	Process Panel Location	MCC Location

NTS: INSERT AT NO. 4 A DESCRIPTION OF LOCAL CONTROL AT EACH PIECE OF EQUIPMENT AS WELL AS SIGNALS AND CONTROLS AVAILABLE AT EACH LOCAL PANEL.

- 1. Local Control:
 - a. (--4--).

NTS: INSERT AT NO. 5 A DESCRIPTION OF THE EQUIPMENT MODULES, WHICH PROVIDE BASIC CONTROL FROM THE SCADA SYSTEM.

- 2. Computer Manual Control:
 - a. (--5--).

NTS: INSERT AT NO. 6 A DETAILED DESCRIPTION OF AUTOMATIC CONTROL OF EACH LOOP. THIS SHOULD INCLUDE DETAILS OF ALL CONTROL SCENARIOS, SUCH AS THE RESPONSE WHEN AN APPARATUS IS NOT IN CCS AT THE LOCAL SELECTOR SWITCH OR THE RESPONSE WHEN

AN APPARATUS IN OPERATION IS SWITCHED TO CCS AT THE LOCAL SELECTOR SWITCH.

3. Computer Automatic Control:
 - a. (--6--).

NTS: DESIGN PROFESSIONAL SHALL COMPLETE THE TABLE BELOW.

4. Interlocks and I/O from other process areas:

Interlock / I/O	Loop #	Response	Local / CCS

NTS: DESIGN PROFESSIONAL SHALL COMPLETE THE TABLE BELOW.

.....

5. SCADA and PLC generated alarms and indications:

NTS: DESIGN PROFESSIONAL SHALL COMPLETE THE TABLE BELOW.

Alarm / Indication	Priority	Comment

6. Set points/data to be entered by the operator at the SCADA System:

NTS: DESIGN PROFESSIONAL SHALL COMPLETE THE TABLE BELOW.

Set point	Range / Typical Value

NTS: INSERT AT NO. 7 A DESCRIPTION OF THE FAULT MODE AND POWER OUTAGE RESPONSES. THIS SECTION WILL DETAIL WHICH EQUIPMENT WILL HAVE BACK-UP POWER AND LIST WHICH EQUIPMENT HAS TO BE OPERATED IN LOCAL CONTROL MODE UNTIL POWER RESUMES. IT WILL ALSO PROVIDE GUIDELINES TO INITIATE AUTOMATIC CONTROL ONCE

POWER HAS BEEN RESUMED. FINALLY, THIS SECTION WILL PROVIDE DETAILS AS TO HOW THE CONTROLS WILL BE AFFECTED IF A FIELD INSTRUMENT (E.G., A pH PROBE OR LEVEL TRANSMITTER) LOOSES ITS SIGNAL.

- 7. Fault Mode and Power Outage response:
 - a. (--7--).

NTS: DESIGN PROFESSIONAL SHALL COMPLETE THE TABLE BELOW.

- 8. Historical Database and Trends:

Description	Trend Tag	Loop Number/s

++ END OF SECTION ++

SECTION 16122
600 VOLT CABLE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals shown, specified, and required to furnish and install 600-volt cable.
2. Types of cable required include:

NTS: EDIT BELOW TO SUIT THE PROJECT.

- a. Insulated cable for installation in raceways.
- b. Cable for installation in trays.
- c.

B. Related Sections:

NTS: LIST BELOW ONLY SECTIONS COVERING PRODUCTS, CONSTRUCTION, AND EQUIPMENT SPECIFICALLY IDENTIFIED IN THIS SECTION AND SPECIFIED IN ANOTHER SECTION AND DIRECTLY REFERENCED IN THIS SPECIFICATION. DO NOT LIST ADMINISTRATIVE AND PROCEDURAL DIVISION 1 SECTIONS. INSERT AT NO. 1 THE NUMBER AND NAME OF THE DIVISION 2 SECTION ON EXCAVATION/EARTHWORK. DESIGN PROFESSIONAL SHALL INSERT OTHER ELECTRICAL SPECIFICATIONS AT NO.s 2 & 3.

1. Section (--1--),
2. Section (--2--), Electrical Identification.
3. Section (--3--), Grounding Systems.

C. Work Included But Specified Elsewhere:

NTS: RETAIN THIS PARAGRAPH ON MULTIPLE-PRIME CONTRACT PROJECTS AND LIST ITEMS INCLUDED UNDER THE ELECTRICAL CONTRACT BUT ARE

SPECIFIED ELSEWHERE. DELETE PARAGRAPH "C" ON SINGLE-PRIME CONTRACT PROJECTS.

1.2 REFERENCES

NTS: RETAIN APPLICABLE STANDARDS AND ADD OTHERS AS REQUIRED.

- A. Standards referenced in this Section are:
 1. UL 44, Thermoset-Insulated Wires and Cables.
 2. UL 1277, Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
 3. ASTM B3, Standard Specification for Soft or Annealed Copper Wire.
 4. ASTM B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft.
 5. ASTM D3485, Standard Specification for Smooth-Wall Coilable Polyethylene Conduit for Preassembled Wire and Cable.
 6. ASTM F2160, Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter.
 7. International Electrical Testing Association (NETA), Acceptance Testing Procedures.
 8. ICEA S-95-658, Non-Shielded Power Cables Rated 2000V or Less.
 9. NEMA TC-7, Smooth-Wall Coilable Electrical Polyethylene Electrical Plastic Conduit.
 10. All applicable local codes and National Electrical Code.

1.3 QUALITY ASSURANCE

NTS: RETAIN APPLICABLE STANDARDS AND ADD OTHERS AS REQUIRED.

- A. Regulatory Requirements:
 1. NEC Article 300, Wiring Methods.
 2. NEC Article 310, Conductors for General Wiring.
 3. Tests by Independent Regulatory Agencies: Cable shall bear the label of the Underwriters' Laboratories, Incorporated.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 1. Product Data:
 - a. Manufacturer's literature, specifications, and engineering data for 600 volt insulated cable proposed for use.
 - b. Manufacturer's literature for cable markers.

- B. Informational Submittals: Submit the following:
 - 1. Field Quality Control Submittals: Written records of field insulation resistance test results.

PART 2 - PRODUCTS

 NTS: RETAIN AND EDIT APPLICABLE PARAGRAPHS UNDER ARTICLE "2.1",
 BELOW, TO SUIT THE PROJECT.

2.1 MATERIALS

- A. Insulated Cable In Raceways:
 - 1. Material: Single conductor copper cable conforming to ASTM B3 and ASTM B8 with flame-retardant, moisture- and heat-resistant insulation rated for 90 degrees C in dry or wet locations, listed by UL as Type XHHW-2 or RHW-2 conforming to UL 44.
 - 2. Application: Use for circuits located indoors and outdoors.

 NTS: FOR APPLICATIONS THAT MAY BENEFIT FROM A CABLE WITH A THICKER INSULATION LAYER, SUCH AS UNDERGROUND DUCTBANKS, CONSIDER USING TYPE RHW-2 CABLE. COORDINATE CONDUIT FILL REQUIREMENTS FOR THE LARGER CABLE DIAMETER. LIMIT RHW-2 USE TO CABLES SIZES LARGER THAN NO. 8 AWG.

- 3. Wire Sizes: Not smaller than No. 12 AWG for power and lighting and No. 14 AWG for 120-volt control circuits.
- 4. Stranding: 600-volt cable shall be stranded, except that solid cable, No. 10 and smaller may be used for lighting circuits.
- 5. Manufacturers: Provide products of one of the following:
 - a. Belden.
 - b. Or equal.

- B. Cable for Installation in Trays:
 - 1. Material: Factory assembled single or multi-conductor control, signal, or power cable that bears UL label Type TC and are specifically approved for installation in cable trays. Overall jacket shall be sunlight resistant PVC. Cable shall be rated for 90 degrees C wet or dry conforming to UL 44 and UL 1277.
 - 2. Manufacturers: Provide products of one of the following:
 - a. Belden.
 - b. Or equal.

D. Cable Connectors, Solderless Type:

1. For wire sizes up to and including No. 6 AWG, use compression type. Alarm and control wire shall be terminated using forked type connectors at terminal boards.
2. Products and Manufacturers: Provide products of one of the following:
 - a. T&B Sta-Kon.
 - b. Burndy Hylug.
 - c. Or equal.
3. For wire sizes No. 4 AWG and above, use either compression type or bolted type with silver-plated contact faces.
4. For wire sizes No. 250 KCMIL and larger, use connectors with at least two cable clamping elements or compression indents and provision for at least two bolts for joining to apparatus terminal.
5. Properly size connectors to fit fastening device and wire size. Connectors shall be rated for 90 degree C, 600 volts.

E. Cable Splices:

1. For wire sizes No. 8 AWG and larger, splices shall be made up with compression type copper splice fittings. Splices shall be taped and covered with materials recommended by cable manufacturer to provide insulation equal to that on conductors.
2. For wire sizes No. 10 AWG and smaller, splices may be made up with pre-insulated spring connectors.
3. For wet locations, splices shall be waterproof. Compression type splices shall be waterproofed by sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring thermosetting resin into mold that surrounds the joined conductor. Spring connector splices shall be waterproofed with sealant filler.
4. Splices shall be suitably sized for cable, rated 90 degrees C, 600 volts.
5. Products and Manufacturers: Provide one of the following:
 - a. Compression-Type Splices:
 - 1) Burndy Hylink.
 - 2) T&B Color-Keyed Compression Connectors.
 - 3) Or equal.
 - b. Spring Connectors:
 - 1) Buchanan B-Cap.
 - 2) T&B Wire Connector.
 - 3) Or equal.

F. Wire and Cable Markers:

1. Provide wire and cable markers in accordance with Section 16075, Electrical Identification.

2.2 SOURCE QUALITY CONTROL

A. Factory Production Tests:

1. Factory-test wire and cable in accordance with UL standards

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cables complete with proper terminations at both ends. Check and correct for proper phase sequence and proper motor rotation.

- B. Pulling:
 - 1. Use insulating types of pulling compounds containing no mineral oil.
 - 2. Pulling tension shall be within limits recommended by wire and cable manufacturer.
 - 3. Use dynamometer where mechanical means are used.
 - 4. Cut off section subject to mechanical means.

- C. Bending Radius: Limit to minimum of six times cable overall diameter.

- D. Slack: Provide maximum slack at all terminal points.

- E. Splices:
 - 1. Where possible, install cable continuous, without splice, from termination to termination.
 - 2. Where required, splice as shown and also where required for cable installation. Splices below grade, in manholes, handholes, and wet locations shall be waterproof.
 - 3. Splices are not allowed in conduits.

NTS: DESIGN PROFESSIONAL TO INSERT CORRECT SPECIFICATION AT NO. 1.

- F. Identification:
 - 1. Identify conductors in accordance with Section (--1--), Electrical Identification.
 - 2. Identify power conductors by circuit number and phase at each terminal or splice location.
 - 3. Identify control and status wiring using numeral tagging system.

NTS: CONFIRM WITH OWNER THAT COLOR CODING SPECIFIED BELOW AGREES WITH OWNER'S STANDARD AND EDIT AS REQUIRED.

- G. Color code power cables as follows:
 - 1. No. 8 AWG and Smaller: Provide colored conductors.
 - 2. No. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, wrapped in overlapping turns to cover an area of at least two inches.

3. Colors: Match color scheme in use at the Site. If the Site does not have an existing color scheme, use the following colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts Single-Phase, Three-Wire	Grounded Neutral	White
	One Hot Leg	Black
	Other Hot Leg	Red
208Y/120 Volts Three-Phase, Four-Wire	Grounded Neutral	White
	Phase A	Black
	Phase B	Red
	Phase C	Blue
240/120 Volts Three-Phase, Four-Wire Delta, Center Tap Ground on Single-Phase	Grounded Neutral	White
	Phase A	Black
	High (wild) Leg	Orange
	Phase C	Blue
480Y/277 Volts Three-Phase, Four-Wire	rounded Neutral	Gray
	Phase A	Brown
	Phase B	Orange
	Phase C	Yellow

3.2 FIELD QUALITY CONTROL

- A. Test each electrical circuit after permanent cables are in place, to demonstrate that circuit and equipment are connected properly and will perform satisfactorily, free from improper grounds and short circuits.
- B. Individually test 600-volt cable mechanical connections after installation and before they are put in service, with calibrated torque wrench. Values shall be in accordance with manufacturer's recommendations.
- C. Individually test 600-volt cables for insulation resistance between phases and from each phase to ground. Test after cables are installed and before they are put in service, with Megger for one minute at voltage rating recommended by cable manufacturer or in accordance with NETA recommendations.
- D. Insulation resistance for each conductor shall not be less than value recommended by cable manufacturer or in accordance with ICEA standards. Cables not meeting recommended value or that fail when tested under full load conditions shall be replaced with a new cable for full length.

 NTS: RETAIN PARAGRAPH "E" WHEN EXISTING CABLES ARE SPLICED TO NEW
 CABLES.

- E. Where existing cables are spliced to cables provided under this Contract, test existing cables prior to splicing. Test cables at 1,000 volts DC for one minute. Entire spliced cable installation shall be re-tested after splice is completed. Existing cable that fails or has value less than two megohms shall be brought to attention of ENGINEER and splicing shall not proceed until condition is acceptable.

+ + END OF SECTION + +