SECTION 13410

PROCESS INSTRUMENTATION AND CONTROLS - GENERAL PROVISIONS

PART 1 GENERAL

1.01 **Summary**

A. Section Includes:

1. A single Instrumentation System Supplier (ISS) shall furnish all services and equipment defined herein and in the following related Specification Sections.

   a. Section 01020 – Work Sequence and Restraints

   b. Section 13411 – CCWD Special Control System Programming and Testing Requirements

   c. Section 13420 – Process Instrumentation and Controls – Products

   d. Section 13421 – Programmable Logic Controllers and Computer Control System

   e. Section 13422 – Control Panels and Panel-Mounted Equipment

   f. Section 13446 - Electronic Operators for Valves and Operator Digital Control System

   g. Section 13482 – Process Control Descriptions

   h. Section 13485 – Instrumentation Equipment List

2. The ISS shall provide all materials, equipment, labor, and services required to achieve a fully integrated and operational system except as noted below. The ISS shall design and coordinate the instrument and control system for proper operation with related equipment and materials furnished by other suppliers under other Sections of these Specifications and with related existing equipment. The ISS shall perform that minimal configuration necessary to the PLC and LOP system to prove proper installation and functionality of the system during the unwitnessed factory test and witnessed factory test.

   a. Programmers for PLC and LOP:

      (1) The District will use their programming contractor to provide DCS programming on this Project. The ISS shall perform that minimal configuration necessary to the PLC and LOP system to prove proper installation and functionality of the system during the unwitnessed factory test and witnessed factory test.

3. Auxiliary and accessory devices necessary for system operation or performance, such as transducers or relays to interface with existing equipment or equipment provided by other suppliers under other Sections of these Specifications, shall be included whether they are shown on the instrumentation or electrical Drawings or not.

4. Substitutions on functions or type of equipment specified will not be acceptable. In order to ensure the interchange ability of parts, the maintenance of quality, the ease of interfacing between the various subsystems and the establishment of minimums with regard to ranges and accuracy, strict compliance with the above requirements shall be maintained. In order to insure compatibility between all equipment, it shall be the responsibility of the ISS to coordinate all interface requirements with mechanical and electrical system suppliers and furnish any signal isolation devices that might be required.

5. Equipment shall be fabricated, assembled, installed and placed in proper operating condition in full conformity with detail Drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer as approved by the Construction Administrator.

6. To facilitate the District's future operation and maintenance, products shall be of the same instrumentation manufacturer, with panel mounted devices of the same type and model to the greatest extent possible.

7. All equipment and installations shall satisfy applicable Federal, State and local codes.

8. Supplementing this Section, the Drawings and the related Specification sections provide additional details showing panel elevations, instrument device schedules, functional requirements of the system and interaction with other equipment.

B. Related Sections:

1. Section 01020 – Work Sequence and Constraints.

2. Division 16 – Electrical.

C. Control System Diagrams And Details

1. To assist the ISS in determining the scope of work, Process and Instrumentation Diagrams (P&IDs) are provided in the Drawings. Unless specifically stated otherwise, the ISS shall be responsible for providing all instrumentation, control equipment and auxiliary devices necessary to perform the functions specified herein and as shown and described on these Drawings. Any auxiliary devices such as lightning/surge protectors, relays, timers, signal isolators, signal boosters, etc., which are necessary for complete operation of the system, or to perform the functions specified shall be included, whether or not they are specifically shown or tabulated on the Drawings or device lists.

2. The intent of the P&IDs is to describe in as much detail as possible, the hardware, software and functional requirements of a process measurement or control system. They are not intended to convey requirements for conduit and wiring between panels or system components. This information is included in appropriate electrical Specifications and Drawings.

3. To assist the ISS in determining the scope of work and intent of the contract documents, written Process Control Descriptions have been included in Section 13482. The control descriptions are general in nature and do not detail all auxiliary devices and interlocks required.

1.02 **References**

A. American Society for Testing and Materials (ASTM):

1. ASTM A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.

B. Instrumentation, Systems, and Automation Society (ISA):

1. ISA S5.2 - Binary Logic Diagrams for Process Operations.

2. ISA S5.3 - Graphic Symbols for Distributed Control/Shared Display Instrumentation Logic and Computer Systems.

3. ISA S5.4 - Instrument Loop Diagrams.

4. ISA S5.5 - Graphic Symbols for Process Displays.

5. ISA S20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.

6. ISA RP60.3 - Human Engineering for Control Centers.

7. ISA RP60.6 - Nameplates, Labels, and Tags for Control Centers.

C. American National Standards Institute (ANSI):

1. ANSI X3.5 - Flowchart Symbols and Their Usage in Information Processing.

D. National Electrical Manufacturers Association (NEMA).

E. National Fire Protection Association (NFPA) - 70, National Electrical Code.

F. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.03 **Submittals**

A. General submittal requirements:

1. All submittals shall be in accordance with Section 01300 and 01340.

2. Shop drawings shall fully demonstrate that the equipment and services to be furnished will comply with the provisions of these specifications and shall provide a true and complete record of the equipment as manufactured and delivered.

3. Submittals shall be bound in separate three-ring binders, with an index and sectional dividers, with all drawings reduced to a maximum size of 11-in by 17-in for inclusion within the binder.

4. Exceptions to the Specifications or Drawings shall be clearly defined by the ISS in a separate section of each submittal package. The submittal shall contain the reason for

exception, the exact nature of the exception and the proposed substitution so that a proper evaluation may be made by the Construction Administrator.

5. Submittals shall include:

   a. Coordination meeting agenda.

   b. Project plan.

   c. ISA loop wiring diagrams.

   e. Conduit riser diagram.

   f. Hardware shop drawings.

   g. Testing plans.

   h. District training plan.

   i. Spares, expendables, and test equipment lists.

   j. ISS qualifications.

B. Coordination Meetings Agenda Submittal

   1. Agendas shall be submitted in accordance with Paragraph 1.08, a minimum of 5 working days prior to the scheduled meeting.

C. Project Plan Submittal

   1. The ISS's project plan shall be submitted and favorably reviewed before any further submittals will be accepted. The project plan shall, as a minimum, contain the following:

      a. Overview of the proposed system.

      b. Approach to work.

      c. Proposed schedule.

      d. Project personnel and organization.

      e. Proposed approach to testing.

      f. Proposed approach to District training.

      g. Preliminary paragraph by paragraph review of the specifications indicating any proposed deviations.

   2. The schedule shall illustrate all major project milestones including the following:

      a. Schedule for all subsequent project submittals.

      b. Tentative dates for all project coordination meetings.

c. Schedule of manufacture of all instrumentation and control system equipment.

d. Schedule for shipment of all instrument and control system equipment.

e. Schedule for all testing.

f. Schedule for equipment start up.

g. Schedule for all training.

3. Prerequisite Activities and Lead Times: The ISS's project schedule shall incorporate the following prerequisite activities and lead times.

a. Hardware purchasing, fabrication, and assembly: associated design related submittals must be favorably reviewed. All relevant loop drawings shall be submitted at least 90 days before the first planned startup of a new or modified system.

b. Factory owner training: District training plan must be favorably reviewed. Factory owner training shall take place before the factory test, but not more than two (2) months before.

c. Factory test: All design-related submittals must be favorably reviewed, unwitnessed factory test procedures favorably reviewed, and the unwitnessed factory test shall be complete. Additionally, all factory owner training must be complete. Give four (4) weeks notice prior to the planned test start date.

d. Shipment to site: Approval of all design-related submittals and, for those instrument system elements that are involved in the factory tests, completion of the factory tests.

e. Field owner training (Pre-Startup): District training plan must be favorably reviewed. Pre-startup training shall take place before startup but not more than 30 days before. Revised preliminary O&M Manuals must be favorably reviewed and ready for use prior to commencing pre-startup Field District Training.

f. Functional acceptance test: Functional acceptance test procedures must be favorably reviewed. Give 30 days notice prior to the planned test start date.

g. Startup: Completion of instrument calibration and functional acceptance tests. Completion of pre-startup field District training.

h. Field owner training (Post-startup): District training plan must be favorably reviewed. Post-startup training shall take place after startup but not more than 30 days after. Final O&M manuals must be favorably reviewed and ready for use prior to commencing post-startup field District training.

I. 30-Day Acceptance Test: Satisfactory completion of functional acceptance test. Field District training must be complete.

D. ISA Loop Wiring Diagrams Submittal:

1. Detailed Instrumentation, Systems, and Automation Society (ISA) loop wiring diagrams showing requirements for each instrument which is furnished under this Section. Also see Drawings.

2. Submittal of generic diagrams will not be acceptable. Loop Drawings shall be prepared in accordance with ISA Standard S5.4 latest edition. Optional items 1, 3, 4, 6, and 7 from the optional list in paragraph 5.3 of S5.4 shall also be provided. Note that the District standard for loop numbering used in these Contract Documents (and as part of the ISS work) does not comply with ISA standards.

3. The loop diagrams shall show all components of the loop including electrical relays, switches, and other devices necessary for the proper operation of the loop. Loop diagrams shall show all wiring and piping details, identify all field termination and grounding points within cabinets and panels, show all PLC I/O terminations, and identify connection points on all devices and identify all wire/cable numbers.

4. Loop diagrams shall be organized in a numerical sequence with each loop detailed on a separate drawing.

E. Conduit Riser Diagram Submittal:

1. A complete conduit riser diagram and conduit schedule shall be prepared and submitted for the interconnection of all equipment specified in this section. The riser diagram and conduit schedule shall detail conduit identification number, size, wires, and location.

2. The conduit riser diagram shall be submitted and favorably reviewed before the Division 16 contractor begins conduit installation.

3. The conduit riser diagrams shall utilize the same identification scheme as used on the Drawings.

F. Hardware Shop Drawing Submittal:

1. Shop Drawings shall be submitted as detailed herein. Submittals consisting of only general sales literature will not be acceptable.

2. The data sheets shall be provided with an index and proper identification and cross-referencing. All devices including in-line equipment, field equipment, and panels and panel equipment shall be included in a comprehensive index.

3. Submit detailed information for each instrument or control device, including manufacturer's descriptive literature and an ISA/S20.3c data sheet for each device. The data sheets shall be provided with an index and proper identification and cross-referencing. All devices including in-line equipment, field equipment, and panels and panel equipment shall be included in a comprehensive index. Include as a minimum:

   a. Plant Equipment Number and ISA tag number per the P&IDs.

   b. Product (item) name as specified and indicated on the Drawings.

   c. Manufacturer's name and complete model number.

d. Location of the device.

e. Input/output characteristics.

f. Range, size, span, setpoint, deadbands, etc.

g. Physical size with dimensions, enclosure NEMA classification and mounting details.

h. Materials of construction of all components.

i. Instrument or control device sizing calculations where applicable.

j. Certified calibration data on all flow metering devices.

4. Hardware Submittals

a. Catalog cuts for RIO and LOP equipment including input modules, output modules, graphical interface panels, modems, network interface modules, and power supplies.

b. Descriptive literature for each hardware component which fully describes the unit being provided.

c. Complete block diagram showing the inter-connections between major hardware components and a complete input/output signal listing.

d. Block diagrams for all hardware components showing the interconnection of all modules, interface devices, modems, and plug in circuit boards.

e. All planning information, site preparation instructions, grounding and bonding procedures, cabling diagrams, plug identifications, safety precautions or guards, and equipment layouts in order to enable the Contractor to proceed with the detailed site preparation for all equipment.

f. Description of communication interfaces between PLCs and associated RIO AND LOP.

5. Control Panels: Submit detailed drawings for all control panels furnished. As a minimum, the drawings shall include:

a. Cabinet assembly and layout drawings to scale. The assembly drawing shall include a bill of material on the drawing with each panel component clearly defined. The bill of material shall be cross-referenced to the assembly drawing so that a non-technical person can readily identify any component of the assembly by manufacturer and model number.

b. Fabrication and painting specifications.

c. Point to point wiring diagrams depicting wiring within the panel as well as connections to external devices.

d. Heat calculations for each panel supplied indicating conformance with specified cooling requirements.

6. Instrumentation Equipment List: An instrument list shall be furnished for all instruments supplied under this Specification Section. The list shall be prepared in MS EXCEL (latest IBM compatible version) format by the ISS. The instrument list submittal shall include both a hard copy printout of the list and a CD-ROM containing this file. The instrument list shall be sorted by loop number. The Instrumentation Equipment List shall contain as a minimum the following:

   a. Full instrument number.

   b. Description (ISA function).

   c. Manufacturer and model number.

   d Scale and setpoint (where applicable).

   e. Physical location.

   f. PLC I/O address (where applicable).

7. Deviation List: A complete list of all deviations proposed shall be included with the submittal. The list shall include a specific but brief written indication of any specific exceptions taken to the interconnection and control intent as shown on the electrical schematics, control descriptions, and specified herein.

G. Software Shop Drawings Submittal

1. Refer to Section 13411 for details.

H. Testing Submittal

1. Outline of Proposed Test Procedure Submittal: Prior to preparation of the detailed testing procedures, submit outlines of the specific proposed tests. Submittals shall include examples of the proposed forms and checklists.

2. Detailed Test Procedure Submittal: After the outlines for the proposed testing have been reviewed by the Construction Administrator and returned stamped either "No Exceptions Noted" or "Approved as Noted", submit the proposed detailed test procedures.

   a. The detailed test procedure submittal shall address each test as required for each test session. The forms and checklist shall indicate applicable test session, i.e., Unwitnessed Factory Test (UFT), Witnessed Factory Test (WFT), etc. Where testing requires simulation indicate proposed method of techniques and equipment to be used to simulate a signal.

   Testing shall begin after review and approval by the Construction Administrator of the proposed detailed test procedures.

3. Submit a proposed "Punchlist/Resolution" form that is required for the Witnessed Factory Test and the Functional Acceptance Test. This form shall include how and when the problem occurred and how the problem was solved. Include specifics such as software documentation, references to manuals, hardware components, etc.

4. Test Result Submittals: The following is the sequence of submittals required during testing. Subsequent testing will not occur until favorable review of the previous test results have been reviewed by the Construction Administrator. The test result submittals review process shall comply with Section 01300.

   a. Unwitnessed Factory Test (UFT) Results.
   b. Witnessed Factory Test (WFT) Results.
   c. Operational Readiness Test (ORT) Results.
   d. Functional Acceptance Test (FAT) Results.

5. All test results shall be kept in a separate Test Results Documentation binder and shall be submitted for review after completion of the 30-Day Test. The Punchlist/Resolution forms shall be included in the Test Results Documentation.

6. Refer to Section 13411 for additional details.

I. ISS Qualifications Submittal

1. Firms desiring to bid for the ISS services and work described in these Specifications shall submit documentation demonstrating compliance with the stated ISS qualifications of 13410-1.04 with their bids to electrical and/or general contractors seeking to bid this Project. The District will not be evaluating the qualifications of firms interested in the ISS role prior to the Notice of Award. The Contractor shall submit documentation proving compliance of the proposed ISS with all qualifications listed in 13410-1.04 to the District within 10 days of the Notice of Award.

1.04 Quality Assurance

A. The Instrumentation System Supplier (ISS) shall be a "systems integrator" or a manufacturer regularly engaged in the design and the installation of instrumentation systems and their associated subsystems as they are applied to the municipal water and wastewater industry. For the purposes of this Specification Section, a "systems house" shall be interpreted to mean an organization that complies with all of the following criteria:

1. Employs a registered professional Control Systems Engineer or Electrical Engineer to supervise or perform the work required by this Specification Section.

2. Employs personnel on this project who have successfully completed ISA or manufacturers training courses on general process instrumentation.

3. Has performed work of similar or greater complexity on at least five previous projects.

4. Has been actively engaged in the type of work specified in this Specification Section for a minimum of the last 5 consecutive years using Modicon "Quantum" hardware, and Modicon "Concept" and Wonderware software packages.

B. For the purposes of this Specification Section, a "manufacturer" shall be interpreted to mean an organization that complies with all of the following criteria:

1. Manufactures at least 50 percent (as measured by equipment cost) of the hardware specified in this section and which is furnished for this project.

2. Complies with the preceding criteria established for a "systems house".

C. The ISS shall maintain a permanent, fully staffed and equipped service facility within 60 miles of the District's headquarters in Concord, California project site with full time employees capable of designing, fabricating, installing, calibrating, and testing the systems specified herein.

D. Actual installation of the instrumentation system need not be performed by the ISS's employees; however, the ISS as a minimum shall be responsible for the technical supervision of the installation by providing on site supervision to the installers of the various components.

E. The ISS shall furnish equipment which is the product of one manufacturer to the maximum practical extent. Where this is not practical, all equipment of a given type shall be the product of one manufacturer.

F. The ISS shall be one of the following:

1. Telstar Inc., Concord, CA.
2. Tesco Controls Inc., Sacramento, CA
3. Krug Bixby Long Associates, Hayward, CA
4. Transdyn, Pleasanton, CA

G. Being listed in this specification does not relieve any potential ISS from meeting the qualifications specified in this Section.

H. The ISS, the manufacturers of the equipment and fabricators of panels and/or cabinets supplied under this Section shall allow the Construction Administrator to inspect and witness the testing of the equipment at the site of fabrication. Equipment shall include the cabinets, special control systems, flow measuring devices and other pertinent systems and/or devices. A minimum of ten working days notification shall be provided to the Construction Administrator prior to testing. No shipments shall be made without the Construction Administrator's prior, written approval.

1.05 System Description

A. Refer to Section 13421 – Programmable Logic Controllers and Computer Control and Section 13482 – Process Control Descriptions.

1.06 Delivery, Storage and Handling

A. Shipping Precautions

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

2. Special instructions for proper field handling, storage and installation required by the manufacturer for proper protection, shall be securely attached to the packaging for each piece of equipment prior to shipment. The instructions shall be stored in resealable plastic bags or other acceptable means of protection.

B. Identification

1. Each component shall be tagged to identify its location, tag number and function in the system. Identification shall be prominently displayed on the outside of the package.

2. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment supplied under this Section.

C. Storage

1. Equipment shall not be stored out-of-doors. Equipment shall be stored in dry permanent shelters including in-line equipment and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the Contractor at his/her own cost and expense. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through such tests as directed by the Construction Administrator. This shall be at the cost and expense of the Contractor, or the apparatus shall be replaced by the Contractor at his/her own expense.

D. Refer to Section 13411 for details on the hardware, software, and schedule for components that shall be delivered to the District's Third Party Integrator.

1.07 Maintenance

A. Spare Parts

1. Spare parts shall be as defined in the related specification sections. All spare parts shall be new and unused.

2. All spare parts shall be individually packaged and labeled.

3. Provide one quart of touch-up paint, in one-quart containers, for each type and color used for all cabinets, panels, consoles, etc, supplied under the related specification sections.

4. The spares listed above shall be packed in a manner suitable for long-term storage and shall be adequately protected against corrosion, humidity and temperature.

1.08 Coordination Meetings

A. The ISS shall schedule a minimum of two (2) mandatory coordination meetings during the shop drawing submittal phase of the project. The meetings shall include as a minimum the Construction Administrator, District, the Contractor's field management, the ISS project engineer, and subcontractors performing any portion of the instrumentation system installation.

1. The first meeting shall be held in advance of the first Section 13410 (and subordinate sections) shop drawing submittal. The purpose of the meeting shall be for the ISS to summarize their understanding of the project, discuss any proposed substitutions or alternatives; schedule testing and delivery milestone dates; and request any additional information required from the District. The ISS shall prepare and distribute an agenda for this meeting a minimum of one week before the scheduled meeting date.

2. The second meeting shall be held after the first Section 13410 shop drawing package has been reviewed by the Construction Administrator and returned to the ISS. The

purpose of the second meeting is to discuss comments made on the submittal package; to refine scheduled milestone dates; and coordinate equipment installation activities. The ISS shall prepare and distribute an agenda for this meeting a minimum of one week before the scheduled meeting date.

1.09 **Final System Documentation**

A. Prior to final acceptance of the system and District training, operating and maintenance manuals covering instruction and maintenance on each type of equipment shall be furnished by the Contractor.

B. The instructions shall be bound in three-ring binders with Drawings reduced or folded for inclusion and shall provide at least the following as a minimum.

1. A comprehensive index.

2. A complete "As Constructed" set of favorably reviewed shop Drawings.

3. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data.

4. Full specifications on each item.

5. System schematic drawings "As Constructed", illustrating all components, piping and electrical connections of the systems supplied under this Section.

6. Detailed service, maintenance and operation instructions for each item supplied.

7. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.

8. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.

9. Complete parts lists with stock numbers and name, address and telephone number of the local supplier.

C. The ISS's final documentation shall be new documentation written specifically for this project, but may include standard and modified standard documentation. All standard documentation furnished shall have all portions that apply clearly indicated. All portions that do not apply shall be lined out.

D. The manuals shall contain all illustrations, detailed drawings, wiring diagrams and instructions necessary for installing, operating and maintaining the equipment. The illustrated parts shall be numbered for identification. All information contained therein shall apply specifically to the equipment furnished and shall only include instructions that are applicable. All such illustrations shall be incorporated within the printing of the page to form a durable and permanent reference book.

E. If the ISS transmits any documentation or other technical information which is considered proprietary, such information shall be designated. Documentation or technical information which is designated as being proprietary will be used only for the design, construction, operation, or maintenance of the system and, to the extent permitted by law, will not be published or otherwise disclosed.

F. The requirements for the ISS's final documentation are as follows:

1. As built documentation shall include all previous submittals, as described in this Specification, updated to reflect the as-built system. Any corrections or modifications to the system resulting from the Factory and/or Field Acceptance Tests shall be incorporated in this documentation.

2. The Hardware Maintenance Documentation shall describe the detailed preventive and corrective procedures required to keep the system in good operating condition. Within the complete Hardware Maintenance Documentation, all hardware maintenance manuals shall make reference to appropriate diagnostics, where applicable, and all necessary timing diagrams shall be included. A maintenance manual or a set of manuals shall be furnished for all delivered hardware, including peripherals. The Hardware Maintenance Documentation shall include, as a minimum, the following information:

   a. Operation Information - This information shall include a detailed description of how the equipment operates and a block diagram illustrating each major assembly in the equipment.

   b. Preventative-Maintenance Instructions - These instructions shall include all applicable visual examinations, hardware testing and diagnostic routines and the adjustments necessary for periodic preventive maintenance of the System.

   c. Corrective-Maintenance Instructions - These instructions shall include guides for locating malfunctions down to the card-replacement level. These guides shall include adequate details for quickly and efficiently locating the cause of an equipment malfunction and shall state the probable source(s) of trouble, the symptoms, probable cause and instructions for remedying the malfunction.

   d. Parts Information - This information shall include the identification of each replaceable or field-repairable module. All parts shall be identified on a list in a drawing; the identification shall be of a level of detail sufficient for procuring any repairable or replaceable part. Cross-references between system supplier's part number and manufacturer's part numbers shall be provided.

3. The Software Maintenance documentation shall provide a detailed description of the entire software system. This documentation shall be sufficient for software maintenance and modification of the entire software system. The following items shall be included with the software maintenance documentation.

   a. System Supplier's User Manuals - All applicable software manuals developed by the system supplier for the application software shall be provided.

   b. Application/Custom Software Manuals - These manual(s) shall include all software maintenance information not included in the computer manufacturer's and system supplier's standard manuals. Each custom program developed specifically for the system shall include the following information as a minimum:

      (1) Table of Contents

      (2) Overview of the program

(3) Narrative describing specifically how the program works. All calculations, references to process I/O points and operator inputs should be mentioned and cross referenced to the logic diagrams or code.

(4) A flowchart shall be provided to clarify the narrative description.

(5) A List of Variables used by the program including the function of each. A cross reference to the Software Functional Design Documentation shall be provided where appropriate.

c. Software Listings - Two sets of well-annotated program listings of all software provided shall be furnished for all software items. These shall include, but not be limited to, the following:

(1) All listings associated with the system generation and software configuration of the specific system (i.e., system parameterization tables, build maps, disk maps, etc).

(2) Listings of all data bases configured for and associated with the system.

(3) Listing of all custom or modified software developed specifically for the system. Listings shall reflect any changes made after the factory acceptance test.

d. Machine Readable Documentation - The supplier shall provide two sets of the following as-built documentation in machine readable format:

(1) CD-ROMs of the entire as-built software system in object format ready to execute on the system. The machine readable documentation shall be 100 percent compatible with the Software Listings previous defined. As with the Software Listings, any changes made during or after factory acceptance test shall be reflected in both the media.

e. Retrofit Documentation - The Supplier shall investigate, diagnose, repair, update and distribute all pertaining documentation of deficiencies which become evident during the warranty period. All such documentation shall be submitted to the District within 30 days of solving the problem.

f. Submit original copies of all application software provided under this Contract. Provide license agreements, serial numbers and product support telephone numbers and access codes as applicable.

4. The Contractor shall provide Operator's Manuals for the system operators and maintenance. These manuals shall be separately bound and shall contain all information necessary for the operator to operate the system. The manuals shall be written in nontechnical terms and shall be organized for quick access to each detailed description of the operator's procedure. Manuals shall contain, but not be limited to, the following information:

a. A simple overview of the entire system indicating the function and purpose of each piece of equipment.

b. A detailed description of the operation of the Graphical Interface Panels including all appropriate displays.

c. A detailed description of the operation and interface of all hardwired panels.

d. Complete step-by-step procedures for starting up and shutting down the entire system.

e. Complete step-by-step procedures for starting up or shutting down an individual component.

f. A complete description of the operation of each plant control function. All operator input to these functions shall be described.

g. A listing of all data base point names with their respective point descriptions.

h. A complete glossary of terms.

i. Complete, step-by-step procedures for performing complete system or selected file backup and restoration.

G. Final documentation shall include the results of all PID controller loop tuning procedures per the requirements of Part 3 of this specification. Submit tuning documentation for all PID loops included in this Contract including all identical loops in parallel process trains.

PART 2 PRODUCTS

2.01 General Requirements

A. Type

1. All instrumentation supplied shall be of the manufacturer's latest design and shall produce or be activated by signals which are established standards for the water and wastewater industries.

2. All electronic instrumentation shall be of the solid-state type and shall utilize linear transmission signals of 4 to 20 mA dc (milliampere direct current), however, signals between instruments within the same panel or cabinet may be 1-5V dc (volts direct current), or the like.

3. Outputs of equipment that are not of the standard signals as outlined, shall have the output immediately raised and/or converted to compatible standard signals for remote transmission. No zero based signals will be allowed.

4. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks as shown on the Drawings or as required.

5. Equipment installed in a hazardous area shall meet Class, Group, and Division as shown on the Electrical Drawings, to comply with the National Electrical Code.

6. All indicators and recorder readouts shall be linear in process units, unless otherwise noted.

7. Electronic equipment shall be of the manufacturer's latest design, utilizing printed circuitry and suitably coated to prevent contamination by dust, moisture and fungus. Solid

state components shall be conservatively rated for their purpose, to assure optimum long term performance and dependability over ambient atmosphere fluctuations and 0 to 100 percent relative humidity. The field mounted equipment and system components shall be designed for installation in dusty, humid, and corrosive service conditions.

8. All equipment, cabinets and devices furnished hereunder shall be heavy-duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, in-so-far as possible and shall consist of equipment models which are currently in production. All equipment provided shall be of modular construction and shall be capable of field expansion.

9. All electronic/digital equipment shall be provided with radio frequency interference protection and shall be FCC approved.

10. All transmitters' output signals shall include signal and power source isolation.

11. All transmitters shall be provided with either integral indicators or close coupled conduit body mounted, line powered indicators calibrated in process engineering units. Indicators shall have an accuracy of two percent of full scale or better.

B. Electrical

1. All equipment shall be designed to operate on a 60 Hertz alternating current power source at a nominal 117 volts, plus or minus 10 percent, except where specifically noted. All regulators and power supplied required for compliance with the above shall be provided between power supply and interconnected instrument loop. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.

2. Materials and equipment used shall be U.L. approved wherever such approved equipment and materials are available.

3. All equipment shall be designed and constructed so that in the event of a power interruption, the equipment specified hereunder shall resume normal operation without manual resetting when power is restored.

2.02 Surge Protection

A. General - Surge protection shall be provided to protect the electronic instrumentation system from induced surges propagating along the signal and power supply lines. The protection systems shall be such that the protective 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 a suitable metallic case, properly grounded. Ground wires for all surge protectors shall be connected to a good earth ground and each ground wire run individually and insulated from each other. These protectors shall be mounted within the instrument enclosure or a separate NEMA 4 junction box coupled to the enclosure. The units shall be as manufactured by Telecommunications Industries Inc.; Joslyn; Leviton; or equal.

B. Power Supply - Protection of all 120 VAC instrument power supply lines shall be provided. Cabinet(s)/panel(s) and groups of field instruments regardless of location (indoor or outdoor), shall be protected by isolation transformers and surge suppressors. Individual field instruments shall be protected by individual gas tube surge suppressors or metal oxide varistors (MOVs).

C. Signal Line - All signal lines when they enter or leave a building shall be protected through the use of gas tube surge arrestors, and Zener diode protectors. These shall be provided at both ends of the signal lines and as close to the instruments as possible.

2.03 **Tubing and Fittings**

A. All instrument air header takeoffs and branch connections less than 2-inches shall be 316 stainless steel.

B. All instrument shut-off valves and associated fittings shall be supplied in accordance with the piping specifications and all instrument installation details. Fittings shall be Swagelok 316 stainless steel or equal and valves shall be Whitey 316 stainless steel or equal.

C. All instrument tubing shall be fully annealed ASTM A269 Seamless 316 grade free of OD scratches having the following dimensional characteristics as required to fit the specific installation:

1. 1/4-inches to 1/2-inches O.D. by 0.035 wall thickness.

2. 5/8-inches to 1-inches O.D. by 0.049 wall thickness.

3. 1-inches O.D. by 0.065 wall thickness.

4. 1-1/4-inches O.D. by 0.065 wall thickness.

5. 1-1/2-inches O.D. by 0.083 wall thickness.

6. 2-inches O.D. by 0.095 wall thickness.

D. All process connections to instruments shall be annealed stainless steel tubing, Type 316.

E. All tube track shall be supported by stainless steel and installed as per manufacturer's installation instructions.

PART 3 EXECUTION

3.01 **General Installation**

A. Instrumentation and accessory equipment shall be installed in accordance with the manufacturer's instructions. The locations of equipment, transmitters, alarms and similar devices shown on the Drawings are approximate only. Exact locations shall be as approved by the Construction Administrator during construction. Obtain in the field all information relevant to the placing of process control work and in case of any interference with other work, proceed as directed by the Construction Administrator and furnish all labor and materials necessary to complete the work in an approved manner.

B. The P&IDs indicate the intent and not the precise nature of the interconnection between the individual instruments. Any exceptions taken to the implied interconnection shall be noted for review by the Construction Administrator.

C. The instrumentation installation details on the Drawings indicate the designed installation for the instruments specified. Where specific installation details are not specified or shown on the Drawings, the American Petroleum Institute (API) Recommended Practice 550 shall be followed as applicable.

D. All work shall be executed in full accordance with codes and local rulings. Should any work be performed contrary to said rulings, ordinances and regulations, the Contractor shall bear full responsibility for such violations and assume all costs arising therefrom.

E. All equipment used in areas designated as hazardous shall be designed for the Class, Group and Division as required on the Electrical Drawings for the locations. All work shall be in strict accordance with codes and local rulings, should any work be performed contrary to said rulings, ordinances and regulations, the supplier shall bear full responsibility for such violations and assume all costs arising there from.

F. Unless specifically shown in the Drawings, direct reading or electrical transmitting instrumentation shall not be mounted on process piping. Instrumentation shall be mounted on instrument racks or stands as detailed on the installation detail drawings. All instrumentation connections shall be provided with shutoff and drain valves. For differential pressure transmitters, valve manifolds for calibration, testing and blowdown service shall also be provided. For slurries, chemical or corrosive fluids, diaphragm seals with flushing connections shall be provided.

G. All piping and tubing to and from field instrumentation shall be provided with necessary unions, calibrations and test tees, couplings, adaptors, and shut-off valves. Process tubing shall be installed to slope from the instrument toward process for gas measurement service and from the process toward the instrument for liquid measurement service. Provide drain/vent valves or fittings at any process tubing points where the required slopes cannot be maintained.

H. Field instruments requiring power supplies shall be provided with local electrical shutoffs and fuses as required.

I. Brackets and hangers required for mounting of equipment shall be provided. They shall be installed in a workmanlike manner and not interfere with any other equipment.

J. The ISS shall investigate each space in the building through which equipment must pass to reach its final location. If necessary, the ISS shall be required to ship his/her material in sections sized to permit passing through restricted areas in the building. The ISS shall also investigate, and make any field modifications to the allocated space for each cabinet, enclosure and panel to assure proper space and access (front, rear, side).

K. The shield on each process instrumentation cable shall be continuous from source to destination and be grounded as directed by the manufacturer of the instrumentation equipment. However, in no case shall more than one ground point be employed for each shield. Unless otherwise necessary, all analog cables shall be grounded in the PLC I/O drop cabinets.

L. Lifting rings from cabinets/assemblies shall be removed. Hole plugs shall be provided for the holes of the same color as the cabinet.

M. The ISS, acting through the Contractor, shall coordinate the installation, the placing and location of system components, their connections to the process equipment panels, cabinets and devices, subject to the Construction Administrator's approval. The ISS shall be responsible to insure that all field wiring for power and signal circuits are correctly done in accordance with best industry practice and provide for all necessary system grounding to insure a satisfactory functioning installation. The Contractor hereunder shall schedule and coordinate his/her work under this section with that of the electrical work specified under applicable Sections of Division 16.

N. Two complete sets of favorably reviewed shop drawings shall be kept at the job site during all on-site construction. Both sets shall be identically marked up to reflect any modifications made during field installation or start-up. All markings shall be verified and initialed by the Construction Administrator or his/her designated representative. Following completion of installation and the operational readiness test, one set of the marked up drawings shall be provided to the Construction Administrator, the other retained by the supplier for incorporation of the mark-ups into final record documentation.

O. Loop Tuning - All electronic control stations incorporating PID controllers shall be tuned following device installation but prior to commencement of the field tests.

1. Optimal loop tuning shall be achieved either by auto-tuning software or manually by trial and error, Ziegler-Nichols step-response method, etc. Assigning common PID factors for identical loops following field tuning of a single typical loop is acceptable. However, tuning documentation shall be submitted for each loop individually as specified in Part 1 of these Specifications.

2. Determine and configure optimal tuning parameters to assure stable, steady state operation of final control elements running under the control of field mounted, dedicated PID controllers or software based PID controllers residing as part of the programmable logic controller system. Each control loop that includes anti-reset windup features shall be adjusted to provide optimum response following startup from an integral action saturation condition.

3. Tune all PID control loops to eliminate excessive oscillating final control elements. Loop parameters shall be adjusted to achieve 1/4 amplitude damping or better. In addition, loop steady state shall be achieved at least as fast as the loop response time associated with critical damping.

4. Loop performance and stability shall be verified in the field following tuning by step changes to setpoint. Submit loop tuning methodology and verification as part of the final system documentation as specified in Part 1.

5. For cascade loops, tune both sets of controllers so that the cascade loop achieves the loop tuning characteristics specified herein.

3.02 **Testing**

A. General

1. As part of the requirement of this specification section it is the responsibility of the ISS to provide a complete operational control system. Confirmation of an operational control system is dependent upon results derived from test procedures as specified in this Section. As part of this contract the ISS shall provide factory testing prior to shipment of the equipment and also testing of the equipment once installed in the field. Once the plant is in operation an additional 30-Day Acceptance Test is required.

2. Each test shall be in the cause and effect format. The person conducting the test shall initiate an input (cause) and upon the system's or subsystem's producing the correct result (effect), the specific test requirement will have been satisfied.

3. All tests shall be conducted in accordance with prior Construction Administrator-approved procedures, forms and checklist. Each specific test to be performed shall be

described and a space provided after it for sign off by the appropriate party after its satisfactory completion.

4. Copies of these sign off test procedures, forms and checklists will constitute the required test documentation.

5. Provide all special testing materials and equipment. Wherever possible, perform tests using actual process variables, equipment, and data. Where it is not practical to test with real process variables, equipment and data, provide suitable means of simulation. Define these simulations techniques in the test procedures.

6. The ISS shall coordinate all required testing with the Contractor, all affected Subcontractors, and the Construction Administrator.

7. The Construction Administrator reserves the right to test or retest all specified functions whether or not explicitly stated in the prior favorably reviewed Test Procedures until the functional requirements of the overall system are met. No additional compensation shall be provided for any required extended testing.

8. The Construction Administrator's decision shall be final regarding the acceptability and completeness of all testing.

9. No equipment shall be shipped until the Construction Administrator has received all test results and approved the system is ready for shipment.

10. The ISS shall furnish the services of field service engineers, all special calibration and test equipment and labor to perform the field tests.

11. Any additional hardware or software that may be required to successfully verify system operation shall be supplied at no cost to the District.

B. Factory Testing

1. Prior to shipment of the equipment the following factory tests are required:

a. Unwitnessed Factory Test (UFT).

(1) The entire system except for primary elements, final control elements, and field mounted transmitters shall be interconnected and tested to ensure the system will operate as specified. All analog and discrete input/output points not interconnected at this time shall be simulated to ensure proper operation of all alarms, monitoring devices/functions and control devices/functions.

(2) All panels, consoles and assemblies shall be inspected and tested to verify that they are in conformance with related submittals, Specifications and Drawings. During the tests all digital system hardware and software shall be operated for at least five days continuously without a failure to verify the system is capable of continuous operation.

(3) Tests to be performed shall include but not be limited to the following. Each of these tests shall be specifically addressed in the Test Procedure submittal.

a) Building and loading the System Data Base.

b) Conduct online modifications to the data base.

c) Demonstrate operability of the interfaces (hardware and software).

d) Demonstrate operability of the data communication network.

e) Demonstrate all system software functions specified.

f) Verify the displays and interactive capabilities of the operator's console.

g) Simulate selected operating conditions to verify the performance of the monitoring and control functions.

h) Generate reports using test data.

i) Verify communication links between all remote sites. Testing of all parameters within the protocol shall be included.

(4) All analog control panels shall be included in these tests.

(5) Submit UFT results for review by the Construction Administrator per Paragraph 1.03H.

b. Witnessed Factory Test (WFT).

(1) Implicit in the scheduling of the witnessed factory acceptance test is the assumption that the ISS has completed the test procedures as defined in the UFT.

(2) All system tests specified for the unwitnessed factory test shall be repeated.

(3) The ISS shall notify the Construction Administrator in writing that the system is ready for the Witnessed Factory Test and allow the Construction Administrator and/or District to schedule a test date within 30 days of receipt of the "Ready To Test" letter. At the time of notification, the ISS shall submit any revisions to the detailed test procedure previously approved by the Construction Administrator in the project system plan.

(4) The purpose of the test shall be to verify the functionality, performance and stability of the hardware and software. The system must operate continually for 100 hours without failure before the test shall be judged successful. Successful completion of this test, as determined by the Construction Administrator, shall be the basis for approval of the system to be shipped to the site.

(5) The various tests performed during the Construction Administrator and/or District witnessed factory demonstration test shall be designed to demonstrate that hardware and software fulfill all the requirements of the Specifications. The test conditions shall resemble, as closely as possible, the actual installed conditions.

(6) During the test for a period of time equal to at least 20 percent of the test duration, the Construction Administrator and/or District's representative shall have unrestricted access to the system.

(7) All deficiencies identified during these tests shall be corrected and retested prior to completing of the Factory Test as determined by the Construction Administrator.

(8) Punchlist items and resolutions noted during the test shall be documented on the Punchlist/Resolution form.

(9) The following documentation shall be made available by the ISS to the Construction Administrator at the test site both before and during the Factory Tests:

a) All Drawings and Specifications, addenda, letters of clarification, and Extra Work authorizations.

b) Master copy of the test procedure.

c) List of the equipment to be tested including make, model and serial number.

d) Design-related hardware submittal applicable to the equipment being tested.

e) Preliminary software documentation submittal.

(10) The daily schedule during these tests shall be as follows:

a) Testing and meetings: Nominally 8 hours per day; 10 hours per day if required to meet schedule.

b) Morning meetings to review the day's test schedule.

c) Evening meetings to review the day's test results and to review or revise the next day's test schedule.

d) Unstructured testing period by the witnesses.

(11) Submit WFT results for review by the Construction Administrator per Paragraph 1.03H – Testing Submittals.

C. Field Testing

1. Prior to plant start up the following tests are required:

a. Operational Readiness Test (ORT)

(1) General: Prior to startup and the Functional Acceptance Test, the entire system shall be certified (inspected, wired, calibrated, tested, etc, and documented) that it is installed and ready for the ORT as defined below.

(2) Loop/Component Inspections and Tests: The entire system shall be checked for proper installation, calibrated and adjusted on a loop-by-loop and component-by-component basis to ensure that it is in conformance with related submittals and these Specifications. Loop tuning shall be completed per Paragraph 3.01.O of this Section.

a) The Loop/Component Inspections and Tests shall be implemented using Construction Administrator-approved forms and checklists.

Each loop shall have a Loop Status Report to organize and track its inspection, adjustment and calibration. These reports shall include the following information and checkoff items with spaces for sign off by the system supplier:

1) Project Name.

2) Loop Number.

3) Tag Number for each component.

4) Checkoffs/signoffs for each component.

- Tag/identification
- Installation
- Termination - wiring
- Termination - tubing
- Calibration/adjustment

5) Checkoffs/signoffs for the loop.

- Panel interface terminations
- I/O interface terminations
- I/O signal operation
- Inputs/outputs operational: received/sent, processed, adjusted
- Total loop operation

6) Space for comments.

(3) Each active Analog Subsystem element and each I/O module shall have a Component Calibration Sheet. These sheets shall have the following information, spaces for data entry and a space for sign off by the system supplier:

a) Project Name.

b) Loop Number.

c) Component Tag Number of I/O Module Number.

d) Component Code Number Analog System.

e) Manufacturer (for Analog system element).

f) Model Number/Serial Number (for Analog system).

g) Summary of Functional Requirements. For example:

- For Indicators and Recorders: Scale and chart ranges
- For Transmitters/Converters: Scale and chart ranges
- For Computing Elements: Function
- For Controllers: Action (direct/reverse) control modes (PID)
- For Switching Elements: Unit range, differential (FIXED/ADJUSTABLE), reset (AUTO/MANUAL)
- For I/O Modules: Input or output

h) Calibrations; for example:

- For Analog Devices: Required and actual inputs and outputs at 0, 10, 50 and 100 percent of span, rising and falling.
- For Discrete Devices: Required and actual trip points and reset points.
- For Controllers: Mode settings (PID).
- For I/O Modules: Required and actual inputs or outputs for 0, 10, 50 and 100 percent of span, rising and falling.

i) Space for comments.

j) Space for sign off by the ISS.

(4) The ISS shall maintain the Loop Status Reports and Components Calibration sheets at the job site and make them available to the Construction Administrator/District at any time.

(5) These inspections and tests do not require witnessing. However, the Construction Administrator will review and initial all Loop Status Sheets and Component Calibration Sheets and spot-check their entries periodically and upon completion of the Operational Readiness Tests. Any deficiencies found shall be corrected.

(6) Submit ORT results for review by the Construction Administrator per Paragraph 1.03H.

b. Functional Acceptance Test (FAT).

(1) Prior to startup and the Functional Acceptance Test (FAT), the entire installed instrument and control system shall be certified that it is ready for operation. All preliminary testing, inspection, and calibration shall be complete as defined in the Operational Readiness Tests.

(2) Once the facility has been started up and is operating, a witnessed FAT shall be performed on the complete system to demonstrate that it is operating and in compliance with these Specifications. Each specified function shall be demonstrated on a paragraph-by-paragraph, loop-by-loop, and site-by-site basis.

(3) Loop-specific and non-loop-specific tests shall be the same as specified under Factory Tests except that the entire installed system shall be tested and all functions demonstrated.

(4) Updated versions of the documentation specified to be provided for during the Factory Tests shall be made available to the Construction Administrator at the job site both before and during the tests. In addition, one copy of all O & M Manuals shall be made available to the Construction Administrator at the job site both before and during testing.

(5) The daily schedule specified to be followed during the Factory Tests shall also be followed during the Functional Acceptance Testing.

(6) The system shall operate for a continuous 100 hours without failure before this test will be considered successful.

(7) Punchlist items and resolutions noted during the test shall be documented on the Punchlist/Resolution form.

(8) Submit FAT results for review by the Construction Administrator per Paragraph 1.03H.

c. 30-Day Acceptance Test

(1) After completion of the Operational Readiness and Functional Acceptance Tests the ISS shall be responsible for operation of each separate process system as it is incorporated into service for a period of 30 consecutive days, under conditions of full plant process operation, without a single non-field repairable malfunction.

(2) During this test, plant operating and ISS personnel shall be present as required. The ISS is expected to provide personnel for this test who have an intimate knowledge of the hardware and software of the system.

(3) While this test is proceeding, the District shall have full use of the system. Only plant operating personnel shall be allowed to operate equipment associated with live plant processes.

(4) Any malfunction during the tests shall be analyzed and corrections made by the ISS. The Construction Administrator and/or District will determine

whether any such malfunctions are sufficiently serious to warrant a repeat of this test.

(5) Any malfunction, during this 30 consecutive day test period, which cannot be corrected within 24 hours of occurrence by the ISS's personnel, or more than two similar failures of any duration, will be considered as a non-field-repairable malfunction.

(6) Upon completion of repairs, by the ISS, the test shall be repeated as specified herein.

(7) In the event of rejection of any part or function, the ISS shall perform repairs or replacement within 60 days or prior to Substantial Completion, whichever occurs first.

(8) All data base errors must be corrected prior to the start of each test period. The 30 day test will not be considered successful until all data base points are correct.

(9) The total availability of the system shall be greater than 99.5 percent during this test period. Availability shall be defined as "Avail. = (Total Time-Down Time) ÷ Total Time".

Down times due to power outages or other factors outside the normal protection devices or backup power supplies provided, shall not contribute to the availability test times above.

3.03 **Training**

A. The cost of training programs to be conducted with District's personnel shall be included in the Contract Price. The training and instruction, insofar as practicable, shall be directly related to the system being supplied.

B. The supplier shall provide detailed manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project.

C. The supplier shall make use of teaching aids, manuals, slide/video presentations, etc. After the training services, such materials shall be delivered to District.

D. The training program shall represent a comprehensive program covering all aspects of the operation and maintenance of the system.

E. All training schedules shall be coordinated with, and at the convenience of the District. Shift training may be required to correspond to the District's working schedule.

F. Factory Training: Factory training shall be conducted before the system is commissioned, and subsequent to final manual submittals. Factory training shall comprise a number of separate courses, whose content and structure is detailed in the individual specification sections. Factory training shall consist of schooling and hands on experience.

G. On-site Training: On-site (field) training shall be conducted at the District's plant site and shall provide detailed hands-on instruction to District's personnel covering; system debugging, program modification, troubleshooting, maintenance procedures, calibration procedures and system operation.

The training shall run at times chosen by the District. The training shall be conducted over a period of three months as follows:

1. One month training during installation but prior to Field Acceptance Test.

2. One month immediately after Field Acceptance Test.

3. Four one-week periods covering preventive and corrective maintenance and trouble-shooting, to be conducted prior to Final Completion.

*****END OF SECTION*****

THIS PAGE INTENTIONALLY BLANK