SECTION 13321

SPECIAL CONTROL SYSTEM PROGRAMMING AND TESTING

1.0   **GENERAL**

1.1   **Summary**

A.   Section Includes:

    1.   Description of Contractor Responsibilities for:

        a.   Interfacing with the System Programmer.
        b.   Control System Delivery.
        c.   Control System Testing.
        d.   Control System Start Up.
        e.   Control System Maintenance.

B.   Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the Contractor and its Sub-Contractors to review all sections to ensure a complete and coordinated project.

C.   In order to maintain interoperability with the existing control system, portions of the control system shall be provided from the named vendor as follows:

    1.   Programmable Logic Controllers: Modicon Momentum

    2.   HMI Software: Wonderware

D.   Scope of Work:

    1.   The Contractor, through the use of its Instrumentation System Subcontractor (ISS), shall be responsible for providing a complete and operating control system. The Contractor shall furnish all labor, material and supervision required to complete the work, except as modified in the paragraphs below.

    2.   Provided by District - The District shall provide the required software and licenses for operating the Wonderware HMI software on the host computer system.

    3.   Work by District's Programmer

        a.   The District, through the services of its representative (Programmer) assigned to perform process control system configuration tasks, will perform the programming and configuration of the SCADA/DCS PLCs and Operator Stations for the Project. The following will not be programmed or configured by the District.

            1)   District will not program the PLCs or local interface displays provided by equipment manufacturers as part of packaged systems.

2) District will not program or configure other programmable devices provided under this contract, such as VFDs, switchgear relays, etc.

b. The District's programming representative, referred to as Programmer, shall operate under the direction of the District.

c. Devices configured under the Programmer's scope of work includes:

1) Existing RTU
2) PLC-1
3) PLC-2
4) PLC-1T
5) PLC-2T
6) PLC-3T
7) OIS
8) Generator controls

d. Programming work excluded from the Programmer's scope of work shall include:

1) PLC Programming for packaged systems described in paragraph 1.01 D5 of this Section.
2) Configuration of Local Operator Interfaces provided as part of the packaged systems described in paragraph 1.01 D5 of this Section.

4. Contractor Responsibilities:

a. The Contractor shall be responsible for all control systems work described in these specifications and drawings, including but not limited to, PLCs, OISs, HMIs, computers, network equipment, and control system software, except for programming and configuration services explicitly specified to be provided by the Programmer herein.

b. The Contractor shall be responsible for all submittals, procurement, assembly, wiring, packing, shipping, installation, set up, startup, specified testing, and as-built drawings for all control system equipment and purchased software.

c. The Contractor, through the services of his equipment suppliers, shall provide all programming and set-up of vendor supplied control panels provided as part of packaged systems.

d. The Contractor shall provide information on packaged systems, as required, to coordinate between control equipment provided under this Contract and services provided by the Programmer.

e. The Contractor shall provide all material, labor and equipment required for a complete and operable control system, except for items specifically excluded from the Contractor's work.

f. The Contractor shall prepare and submit for approval complete Loop Diagram, I/O Elementary and other drawings as required.

g. The Contractor shall test the PLC I/O system as specified herein to

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verify proper performance independent of the use of the software provided by the Programmer.

h. The Programmer and Contractor shall perform certain control system and start-up tests jointly to ensure proper system operation. For tests that are conducted jointly, the Contractor shall provide appropriate full-time on-site support. The Contractor shall maintain familiarity with the Control Strategy Descriptions to support the startup and testing activities.

i. The Contractor shall provide the communications network as specified herein and indicated on the Drawings and other sections of the specification.

j. The Contractor shall perform testing and training as described in Part 3 below.

5. Packaged control systems provided as part of this project include:

a. Generator Control Panel

b. As otherwise indicated on the Contract Drawings.

6. The Contractor shall coordinate the Work between the Contractor's equipment vendors and the Programmer. Each equipment and packaged system vendor supplying control system components shall be provided with a complete set of Instrumentation and Control System Division 13 documents and drawings prior to bidding, such that vendor provided control work adheres to the same specifications and requirements as the work performed by the Instrumentation System Subcontractor (ISS)under the requirements of Division 13.

7. The Contractor shall provide, for use by the Programmer, complete documentation of all vendor provided control system components including:

a. Control Strategy Descriptions.

b. Electrical drawings.

c. PLC I/O lists.

d. PLC memory maps.

e. Documented program listings.

f. Operating instructions.

g. Supplemental information.

Note that this information may overlap drawing requirements required as part of an Operation and Maintenance manual submittal, however, this information shall be provided per the early delivery schedule provided in Part 3 of this Section.

1.2 References

A.   This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there   are   no

replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
API RP 551	Process Measurement Instrumentation
ASTM A312/A312M	Seamless and Welded Austenitic Stainless Steel Pipes
ANSI B16.5	ASME Pipe Flanges and Flanged Fittings
IEEE 100	Dictionary of Electrical and Electronics Terms
ISA 5.4	Instrument Loop Diagrams
ISA 51.1	Process Instrumentation Terminology
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	General Standards for Industrial Control and Systems
NEMA ICS 2	Industrial Control Devices, Controllers, and Assemblies
NFPA 70	National Electrical Code (NEC)
UBC	Uniform Building Code
UL 1012	Power Supplies

1.3 Definitions

A.   Where a term is used in specification section number series 13300 through 13447A relating to instrumentation, and the meaning is not defined therein or elsewhere in the Contract Documents, the meaning of the term shall be as defined in ISA S51.1 Process Instrumentation Terminology, or if not contained in ISA 51.1, as defined in listed reference standards under "References".

B.   CEET - Complete End to End Testing.

C.   Programmer – A control systems specialist hired by the District to provide programming services as defined in other portions of this Section.

D.   ISST – Integrated Software Shop Testing.

E.   ISS – Instrumentation System Subcontractor. The Instrumentation System Subcontractor (ISS) is subcontracted by the Contractor for the purpose of providing the instrumentation subsystems.

F.   LOI - Local Operator Interface

G.   NAT - Network Acceptance Testing.

H.   Panel: An instrument support system which may be either a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Unless otherwise specified or clearly indicated by the context, the term "panel" in these Contract Documents shall be interpreted as a general term, which includes flat panels, enclosures, cabinets and consoles.

I.   OIS: Operator Interface Station

J.   PPFT - PLC Panel Factory Testing.

K.   PPIT - PLC Panel Installation Testing.

L.   SFT - Strategy Field Testing.

1.4   Submittals

A.   Furnish complete submittals in accordance with Sections 01300 and 13300 and as listed below.

B.   Test Procedure Submittals:

1.   Submit the procedures to be followed during the test. Procedures shall include test descriptions, forms, and checklists to be used to control and document the required tests. (Refer to Part 3 of this Section for testing requirements).

   a.   Preliminary test procedure submittals: Prior to the preparation of the detailed test procedures, submit outlines of the specific proposed tests. Submittals shall include examples of the proposed forms and checklists.

   b.   Test Procedure Submittals: After the preliminary test procedure submittals have been reviewed by the Construction Administrator and returned stamped either "approved" or "approved as noted, confirm" submit the proposed detailed test procedures. Following this, the tests may be started.

2.   Test Documentation: Upon completion of each required test, the Contractor shall document the test by submitting a copy of the signed off test procedures.

3.   The Contractor shall develop and submit test plans and forms for all tests

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specified in this section, as well as all other control system related testing, except for the ISST and SFT tests. ISST and SFT test forms will be provided by the District, through the services of the Programmer.

2.0 NOT USED

3.0 EXECUTION

3.1 Early Delivery Items

A. The Contractor shall expedite the approval and purchase of any of the following equipment items which fall under the Contractor's scope of supply. These items shall include, but not be limited to:

    1. PLCs, including racks, power supplies and cards.

    2. Workstations.

    3. Communications Components.

    4. Configuration Software.

    5. Local Operator Interfaces.

    6. Other items, as required, for a complete control system.

3.2 Coordination Meetings

A. In addition to the regular progress meetings, a minimum of three (3) coordination meetings shall be scheduled to coordinate the project control system software work. The District, the Contractor, the Programmer and appropriate packaged system manufacturers shall be in attendance.

B. Manufacturer's representatives shall have experience with the packaged system control components and software.

C. The first meeting shall be scheduled when approximately one-third of the contract time has elapsed to review Control Software interfaces between the District's Programmer's work and the Contractor's work. Equipment deliveries and initial start-up issues shall also be discussed.

D. The second meeting shall be conducted when one-half to three-quarters of the contract time has elapsed.

E. The final meeting shall be scheduled to review operational constraints associated with testing and start up of the control system and related process equipment.

3.3 Testing

A. Tests (General)

    1. As a minimum, testing shall include the following:

        a. Unwitnessed Factory Tests (UFT).

        b. Witnessed Factory Tests (WFT).

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c. Operational Readiness Tests (ORT).

d. Functional Acceptance Tests (FAT).

e. 30-Day Acceptance Tests.

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 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 simulation techniques in the test procedures.

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

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

8. No control equipment shall be shipped until the Construction Administrator has received all test results, reviewed them, and given approval to ship the equipment.

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

10. Any testing or startup activity that requires the participation of the Programmer shall be scheduled by the Contractor through written notification to the Construction Administrator and Programmer. Contractor shall provide regularly updated testing and startup schedules to the Construction Administrator. In addition to any other form of notification, Contractor shall notify Programmer by email, or other mutually agreed upon means, two working days immediately prior to any testing or other activity requiring the participation of the Programmer. Failure to properly notify Programmer shall result in rescheduling of test activity, solely at Contractor expense and without an extension to the project completion schedule.

11. Testing and startup activities must be scheduled around treatment plant operating needs. Testing and startup activities will require significant

coordination with plant staff and scheduling around facility operational constraints. Startup restrictions and requirements in this Section are minimums. Additional requirements are specified in other Sections of the Contract Documents.

12. The Contractor shall not start any testing activity that cannot be completed by the end of the work week if so doing would disrupt treatment operations. Testing and startup activities shall not be conducted on Fridays or working days immediately prior to an District staff holiday.

13. Testing and startup shall be scheduled to allow proper operations staff training by the Contractor and Construction Administrator prior to putting equipment into regular service.

B. Unwitnessed Factory Tests (UFT)

1. The control system equipment, except for primary elements, final control elements, and field mounted transmitters, shall be interconnected and tested by the Contractor to ensure the system will operate as specified.

2. The purpose of the test shall be to verify the functionality, performance and stability of the hardware. The system must operate continuously for 48 hours trouble free.

3. All panels, consoles and assemblies shall be inspected and tested to verify that they are in conformance with related submittals, Specifications and Drawings. All analog and discrete input/output points shall be simulated to ensure proper wiring.

4. During the tests all digital system hardware shall be operated for at least five days continuously without a failure to verify the system is capable of continuous operation.

C. Witnessed Factory Test (WFT)

1. Implicit in the scheduling of the witnessed factory test (WFT) is the assumption that the Contractor has determined through prior, unwitnessed tests and quality assurance programs that the equipment is ready for shipment.

2. Prior to start of the WFT, all previous unwitnessed test results and forms shall have been submitted to the Construction Administrator for review and approval.

3. As part of the factory testing, all PLC system components shall be assembled and tested in their enclosures at the Contractor's panel assembly facility, which shall be located no more than 100 miles from Concord, California. The test set up shall include a temporary network that includes all network components.

4. The Contractor shall notify the District and Construction Administrator in writing that the system is ready for the WFT and allow the District and Construction Administrator to schedule a test date within 21 days of receipt

of the "Ready to Test" letter. At the time of notification, the Contractor shall submit any revisions to the detailed test procedure previously approved by the Construction Administrator in the project system plan.

5. The purpose of the test shall be to verify the functionality, performance and stability of the hardware. The system must operate continuously for 96 hours trouble free. Successful completion of this test, as determined by the District and Construction Administrator, shall be the basis for approval of the system to be shipped to the site.

6. All system tests specified for the unwitnessed factory test (UFT) shall be repeated. Additional tests shall be performed. All temporary cabling provided during the UFT shall be provided for the WFT. This includes a 100 percent check of all I/O to the interface terminal blocks and verification of all communications networks.

7. The various tests performed during the WFT shall be designed to demonstrate that hardware fulfills all the requirements of the specifications. The test conditions shall resemble, as closely as possible, the actual installed conditions. Any additional hardware or software that may be required to successfully verify system operation shall be supplied at no additional cost.

8. A complete system checklist shall be available during the test for recording results of selected points.

9. During the test for a period of time equal to at least 20 percent of the test duration, the Construction Administrator and Programmer shall have unrestricted access to the system to perform ad hoc testing.

10. All control panels shall be included in these tests.

11. Perform PLC Panel Testing (PPFT) (by Contractor). The test shall confirm that all control system equipment has been completely and correctly assembled prior to shipment to the field. The panel shall be physically inspected for proper construction, assembly, wire tagging, fusing, labeling and general workmanship. Electrical tests shall be performed to verify the proper operation of all components and that the connections are correct from the field terminals to the PLC registers. The Contractor shall provide an additional computer for testing purposes with additional PLC programming software installed, connect it to the PLC being tested, and perform the tests. Any computers and software delivered to the District or Programmer shall not be used for this purpose. After the completion of the electrical testing procedures, each cabinet shall remain energized for a period of not less than 24 hours, without component failures, prior to shipment from the factory.

12. Integrated Software Shop Testing (ISST) (Joint Programmer and Contractor test). After the completion of the PPF Testing, the Programmer shall load the process control software into the PLC and demonstrate the operation of the control system software. The testing shall take place at the Contractor's facility. The Contractor shall allow approximately 1 work day in the Construction Schedule (per Section 01310 - Process Schedule) per 50

physical I/O points to accommodate ISST Testing. The Contractor shall provide full time personnel to support the activities of the Programmer during this test. The District reserves the right to waive the ISST, without penalty.

13. Any components found to be defective during the PPFT or the ISST shall be replaced or repaired by the Contractor prior to shipment to the project site.

14. All deficiencies identified during these tests shall be corrected and retested prior to completion of the WFT as determined by the District and Construction Administrator.

15. The following documentation shall be made available by the Contractor to the Construction Administrator and Programmer at the test site both before and during the WFT:

    a. All drawings and specifications, addenda and change orders.

    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 and software submittal applicable to the equipment being tested.

16. All test data and results shall be logged by the Contractor, and certified copies of the logs shall be provided to the Construction Administrator.

17. The "punch list" of deficiencies shall be corrected prior to equipment shipment to the job site.

D. Operational Readiness Tests (ORT)

1. General: Prior to startup and the Functional Acceptance Test, the entire system shall be certified (inspected, tested and documented) by the Contractor that it is ready for operation. Note that the control system testing includes the operation of equipment items outside of the Division 13 scope of work. The Contractor shall coordinate the construction activities such that instrumentation and equipment items are operable during the testing period. Operational Readiness testing shall not begin until permanent power, and other service connections, are provided for all equipment items. For equipment items requiring vendor provided start up services, this work shall be coordinated to maximize the effectiveness of the field tests.

2. PLC Panel Installed Testing (PPIT) (by Contractor)

    a. The Contractor shall inspect the installed PLC cabinets and verify the following:

       1) The cabinet and components are not damaged.

       2) All components are installed and wiring has been completed.

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        3)   All fuses are installed in fuse holders.

        4)   Cabinet wiring is free from short circuits.

   b.   The Contractor shall energize the cabinets and power up the components.

   c.   The Contractor shall verify that all power supplies are operating properly.

   d.   The Contractor shall verify that all PLC cards are installed and functional; and that the PLC is ready to accept the PLC program.

   e.   Provide written certification that PPIT has been completed satisfactorily prior to scheduling or starting BEET or loop acceptance testing.

3.   Basic End-to-End Testing (BEET) (by Contractor)

   a.   For each and every analog and discrete circuit, the Contractor shall perform Basic End-to-End Testing (BEET). This includes, but is not limited to, all local control panels, MCCs, and hardwired circuits in control panels.

   b.   Connect a computer equipped with PLC programming software to the associated PLC.

   c.   For each input, activate the signal at the primary field device, either by creating necessary process and equipment conditions or by disconnecting the wires at the field device and simulating the input signal. At the PLC, using the PLC programming software, verify proper receipt of the signal.

   d.   For each output signal from the PLC, activate the PLC output signal using the PLC programming software, and verify proper receipt of the signal at the controlled device in the field, either by observing equipment operation or by disconnecting the wires at the equipment and verifying proper receipt of the signal.

   e.   Verify proper signal receipt at all intermediate devices, such as indicators, signal trip and relay modules, etc.

4.   Loop/Component Inspections and Tests (by Contractor)

   a.   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.

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

   c.   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 check off items with spaces for sign off by test personnel:

        1)   Project Name.

2) Loop Number.

3) Tag Number for each component.

4) Check offs/signoffs for each component:

    a) Tag/identification.

    b) Installation.

    c) Termination - wiring.

    d) Termination - tubing.

    e) Calibration/adjustment.

5) Signoffs/signoffs for the loop:

    a) Panel interface terminations.

    b) I/O interface terminations.

    c) I/O signal operation.

    d) Inputs/outputs operational: received/sent, processed, adjusted.

    e) Total loop operation.

6) Space for comments.

d. 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:

1) Project Name.

2) Loop Number.

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

4) Component Code Number Analog System.

5) Manufacturer (for Analog system element).

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

7) Summary of Functional Requirements. For example:

    a) For Indicators and Recorders: Scale and chart ranges

    b) For Transmitters/Converters: Scale and chart ranges

    c) For Computing Elements: Function

    d) For Controllers: Action (direct/reverse) control modes (PID)

    e) For Switching Elements: Unit range, differential (FIXED/ADJUSTABLE), reset (AUTO/MANUAL)

    f) For I/O Modules: Input or output

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8) Calibrations; for example:

    a) For Analog Devices: Required and actual inputs and outputs at 0, 25, 50, 75 and 100 percent of span, rising and falling.

    b) For Discrete Devices: Required and actual trip points and reset points.

    c) For Controllers: Mode settings (PID).

    d) For I/O Modules: Required and actual inputs or outputs for 0, 10, 25, 50, 75 and 100 percent of span, rising and falling; 9 points calibration (5 points calibration will be rejected).

9) Space for comments

10) Space for sign off by test personnel.

e. The Contractor 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. Complete End-to-End Acceptance Tests (CEET) (joint Contractor and Programmer test, except for vendor control panels):

a. For each PLC, CEET testing shall not commence until all Loop Acceptance Tests for the PLC have been satisfactorily completed, and all test results (including all forms signed off) have been submitted for review and accepted.

b. For each and every analog and discrete circuit, perform an end-to-end test between the field device and the SCADA/DCS computer operator station, and including all intermediate readouts. Also test each signal circuit transmitted over digital networks (i.e. valve networks, RS-422 links, etc.)

c. Where PLC-based control units have been programmed by equipment vendors and provided by the Contractor, this test shall be performed by the Contractor. During the test, the Contractor shall have on site a technician from the vendor's company who can make changes to the PLC code provided by the vendor.

d. In general, the end-to-end testing is a two or more person test. The Contractor shall provide personnel to operate equipment or simulate signals that are to be verified as part of this test. The Programmer shall operate the SCADA/DCS operator station(s).

e. Check each loop from the field element to the respective computer control display. Include all intermediate field instruments, control devices, panels, indicators and other devices in the loop to ensure proper operation and linkage to computer control station displays.

f. Analog signals shall be tested at 0, 50, and 100 percent of scale to verify the proper receipt on computer control displays.

g. Discrete input circuits shall be tested to verify proper state when the field device is switched between states. Discrete output circuits shall be

tested to verify equipment responds properly (start, stop, etc.).

    h.   Contractor shall provide adequate time in the Construction Schedule for CEET testing.

E.   Functional Acceptance Test (FAT) (Joint Programmer and Contractor test)

    1.   All preliminary testing, inspection, and calibration shall be complete as defined in the Operational Readiness Tests prior to startup and the Functional Acceptance Test (FAT)

    2.   Strategy Field Testing (SFT):

        a.   This test shall be performed by the Programmer with the assistance and cooperation of the Contractor. The Contractor shall provide a qualified start-up and testing representative on-site, assisting and participating in the testing full-time, for the duration of the SFT.

        b.   The Contractor shall include in the Construction Schedule at least two days of SFT testing work for each of the control strategy in Section 13000 - Control Strategy Descriptions, or at least 1.5 days per P&ID drawing, whichever is greater, and shall provide staff for these periods, as required above for this work.

        c.   For each control strategy and for each electrical schematic diagram, demonstrate the proper operation of all hardware and software logic and control functions. Perform a step by step test of each function described in each control strategy.

        d.   Perform separate tests on each individual piece of equipment, and for each control loop.

        e.   Perform the proper operation of each discrete control loop to ensure the proper operation of motors, hand switches, interlocks, solenoid valves, other auxiliary devices, status lights, computer control operator interfaces, and alarms.

    3.   Updated versions of all wiring documentation shall be made available at the job site both before and during the tests. In addition, one copy of all O&M Manuals shall be made available at the job site both before and during testing.

    4.   The system shall operate for a continuous 96 hours without failure before this test will be considered successful.

END OF SECTION