

SECTION 01660
PERFORMANCE AND OPERATIONAL TESTING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Performance testing and documentation for mechanical, electrical, instrumentation, and HVAC systems.

1.2 RELATED SECTIONS

- A. Section 01770 – Closeout Procedure
- B. Division 15 - Mechanical
- C. Division 16 - Electrical

1.1 SUBMITTALS

- A. Submit under provisions of Section 01330.
- B. A complete description for documenting the results from the test program including:
 - 1. Proposed plan for documenting the calibration of all test instruments.
 - 2. Proposed plan for calibration of all instrument systems including flow meters, and all temperature, pressure, weight and analysis systems.
 - 3. Sample forms for documenting the results of field pressure and performance tests.
- C. The credentials and certification of the testing laboratory for calibration of all test equipment.
- D. Preoperational check-out procedures, reviewed and approved by the respective equipment manufacturers.
- E. Detailed testing plans, setting forth step-by-step descriptions of the procedures for the systematic testing of all equipment and systems installed under this contract.
- F. A schedule and subsequent updates, presenting the contractor's plan for testing the equipment and systems installed as part of this Project.
- G. A schedule establishing the expected time period (calendar dates) when the Contractor plans to commence operational testing of the completed systems, along with a description of the temporary systems and installations planned to allow operational testing to take place.

1.2 CALIBRATION

- A. All test equipment (gages, meters, thermometers analysis instruments, and other equipment) used for calibrating or verifying the performance of equipment installed under this contract shall be calibrated to within plus or minus two percent of actual value at full scale.
- B. Select test equipment employed for individual test runs so that expected values as indicated by the detailed performance specifications will fall between 60 and 85 percent of full scale.
- C. Select pressure gages in accordance with ANSI/ASME B40.1.
- D. Select thermometers in accordance with ASTM E77 and furnish with a certified calibration curve.
- E. Liquid flow meters, including all open channel flow meters and all meters installed in pipelines with diameters greater than two inches insitu using either the total count or dye dilution methods.
- F. Gas flow meters installed in piping systems with diameters greater than six inches insitu using the pitot tube velocity averaging method.
- G. Flow meter calibration work performed by individuals skilled in the techniques to be employed.
- H. Calibration tests for flow metering systems performed over a range of not less than 10 percent to at least 75 percent of system full scale.
- I. At least five confirmed valid data points obtained within this range. Confirmed data points validated by not less than three test runs with results which agree within plus or minus two percent.

1.3 REFERENCES

- A. In case of a conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.
- B. ASNI/ASME B40.1-85 - Gauges Pressure Indicating Dial Type --Elastic Element
- C. ASTM E77-84 - Method for Verification and Calibration of Liquid-in-Glass Thermometers
- D. ASHRAE 41.8 - Standard Methods of Measurement of Flow of Gas
- E. Dye Dilution Calibration Method - Flow Measurements in Sanitary Sewers By Dye Dilution, Turner Designs, Mountain View, California.
- F. Flow Measurement in Sewer Lines by the Dye Dilution Method, Journal of the Water Pollution Control Federation, Vol. 55, Number 5, May, 1983, pg. 531
- G. Flow Measurement in Open Channels and Closed Conduits, Vol 1, U.S. Department of Commerce, National Bureau of Standards, pg. 361.
- H. Techniques of Water-Resources Investigations of the United States Geological Survey, Chapter 16, Measurement of Discharge Using Tracers

PART 2 PRODUCTS

2.1 GENERAL

- A. Prepare test plans and documentation plans as specified in the following paragraphs. Engineer will not witness any test work for the purpose of acceptance until all test documentation and calibration plans and the specified system or equipment test plans have been submitted and accepted.

2.2 DOCUMENTATION PLANS

- A. Develop a records keeping system to document compliance with the requirements of this Section. Calibration documentation shall include identification (by make, manufacturer, model, and serial number) of all test equipment, date of original calibration, subsequent calibrations, calibration method, and test laboratory.
- B. Equipment and system documentation shall include date of test, equipment number or system name, nature of test, test objectives, test results, test instruments employed for the test and signature spaces for the Engineer's witness.
- C. Establish a separate file shall be established for each system and item of equipment. These files include the following information as a minimum:
 - 1. Metallurgical test
 - 2. Factory performance test
 - 3. Accelerometer recording made during shipment
 - 4. Field calibration tests
 - 5. Field pressure tests
 - 6. Field performance tests
 - 7. Field operational tests
- D. Develop test documentation forms specific to each item of equipment and system installed under this Project. Acceptable documentation forms for all systems and items of equipment shall be produced for review by Engineer as a condition precedent to the Contractor's receipt of progress payments in excess of 50 percent of the contract amount.
- E. Once Engineer has reviewed and taken no exception to the forms proposed by Contractor, provide sufficient forms, to provide documentation of all testing work to be conducted as a part of this Project.

2.3 TEST PLANS

- A. Develop test plans detailing the coordinated, sequential testing of each item of equipment and system installed under this project, specific to the item of equipment or system to be tested.
- B. Identify, by specific equipment or tag number, each device or control station to be manipulated or observed during the test procedure and the specific results to be observed or obtained. Support systems required to complete the test work, temporary systems required during the test work, subcontractors' and manufacturers' representatives to be present and expected test duration.
- C. As a minimum, include the following features:
 - 1. Step-by-step proving procedure for all control and electrical circuits by imposing low voltage currents and using appropriate indicators to affirm that the circuit is properly identified and connected to the proper device.
 - 2. Calibration of all analysis instruments and control sensors.
 - 3. Performance testing of each individual item of mechanical, electrical, and instrumentation equipment. Performance tests shall be selected to duplicate the operating conditions described in these specifications.
 - 4. System tests designed to duplicate, as closely as possible, operating conditions described in these specifications.
- D. Contain a complete description of the procedures to be employed to achieve the desired test environment.
- E. Reproduce the plans in sufficient number for Contractor's purposed and an additional 10 copies for delivery.
- F. Test work shall not begin until Contractor has delivered the final test plans to Engineer.

2.4 TESTING SCHEDULE

- A. Produce a testing schedule setting forth the sequence contemplated for performing the test work. The schedule shall be in bar chart form, plotted against calendar time, shall detail the equipment and systems to be tested, coordinated with Contractor's construction schedule.
- B. Show the contemplated start date, duration of the test and completion of each test. Submit the test schedule no later than four weeks in advance of the date testing is to begin.
- C. Engineer will not witness any testing work for the purpose of acceptance until the Contractor has submitted a final schedule.
- D. Update weekly, showing actual dates of test work, indicating systems and equipment testing completed satisfactorily and meeting the requirements of these specifications.

2.5 SYSTEM AND EQUIPMENT PERFORMANCE TESTS

- A. Test each item of mechanical, electrical, instrumentation, and HVAC equipment installed under this project to demonstrate compliance with the performance requirements.
- B. Test each electrical, instrumentation, mechanical, piping, and HVAC system installed or modified in accordance with the requirements of these specifications.

2.6 OPERATIONAL TESTS

- A. Once all equipment and systems have been tested individually, fill all systems with the intended process fluids. Wastewater-derived process systems shall be filled with water.
- B. After filling operations have been completed, operate all systems for a continuous period of no less than 60 days, simulating actual operating conditions to the greatest extent possible.
- C. Install temporary connections, bulkheads and make other provisions to recirculate process fluids or otherwise simulate anticipated operating conditions.
- D. During the operational testing period, Contractor and testing team are to monitor the characteristics of each machine and system and report any unusual conditions to Engineer.

2.7 PRODUCT DATA

- A. Product data, to be provided in accordance with Section 01330, shall be the original and three copies of all records produced during the testing program.

PART 3 EXECUTION

3.1 GENERAL

- A. Contractor shall organize teams made up of qualified representatives of equipment suppliers, subcontractors, Contractor's independent testing laboratory, and others, as appropriate, to efficiently and expeditiously calibrate and test the equipment and systems installed and constructed under this contract.
- B. The objective of the testing program is to demonstrate, to Engineer's complete satisfaction, that the structures, systems, and equipment constructed and installed under this contract meet all performance requirements and the facility is ready for the commissioning process to commence.
- C. In addition, testing program, produce baseline operating conditions for Owner to use in a preventive maintenance program.

3.2 CALIBRATION OF FIXED INSTRUMENTS

- A. Calibrate analysis instruments, sensors, gages, and meters installed on a system-by-system basis. No equipment or system performance acceptance tests is to be performed until instruments, gages, and meters to be installed in that particular system have been calibrated and the calibration work has been witnessed by Engineer.
- B. All analysis instruments, sensors, gages, and meters used for performance testing shall be subject to recalibration to confirm accuracy after completion, but prior to acceptance of each performance test.
- C. All analysis instruments, sensors, gages, and meters installed under this Project are subject to recalibration as a condition precedent to commissioning.

3.3 PRESSURE AND LEAKAGE TESTS

- A. Conduct in accordance with applicable portions of Division 15. All acceptance tests shall be witnessed by Engineer.
- B. Evidence of successful completion of the pressure and leakage tests shall be Engineer's signature on the test forms prepared by Contractor.

3.4 FUNCTIONAL CHECKOUT (ELECTRICAL SYSTEMS)

- A. Prior to energization, all circuits are to be rung out and tested for continuity and shielding in accordance with the procedures required in Division 16.

3.5 COMPONENT CALIBRATION AND LOOP TESTING (INSTRUMENTATION)

- A. Prior to energization, all loops and associated instruments are to be calibrated and tested in accordance with the procedures required in Division 16.

3.6 ELECTRICAL RESISTANCE

- A. Test electrical resistance be in accordance with Division 16.

3.7 PREOPERATIONAL TESTS

- A. Alignment of equipment using reverse dial indicator method.
- B. Pre-operational lubrication.

- C. Tests per manufacturer's recommendations for pre-start preparation and pre-operational check-out procedures.

3.8 FUNCTIONAL TESTS

- A. Once all affected equipment has been subjected to the required preoperational check-out procedures and Engineer has witnessed and has not found deficiencies in that portion of the work, individual items of equipment and systems may be started and operated under simulated operating conditions to determine as nearly as possible whether the equipment and systems meet the requirements of these specifications.
- B. If available, plant effluent may be employed for the testing of all liquid systems except gaseous oil, or chemical systems. If not available, potable water shall be employed as the test medium.
- C. Test media for these systems can either be the intended fluid or a compatible substitute.
- D. Operate the equipment a sufficient period of time to determine machine operating characteristics, including noise, temperatures and vibration; to observe performance characteristics; and to permit initial adjustment of operating controls.
- E. When testing requires the availability of auxiliary system such as looped piping, electrical power, compressed air, control air, or instrumentation which have not yet been placed in service, provide acceptable substitute sources, capable of meeting the requirements of the machine, device, or system at no additional cost to Owner. Disposal methods for test media is subject to review by Engineer.
- F. During the functional test period, obtain baseline operating data on all equipment with motors greater than one horsepower to include amperage, bearing temperatures, and vibration. The baseline data shall be collected for Owner to enter in a preventive maintenance system.
- G. Test results shall be within the tolerances set forth in the specification. If no tolerances have been specified, test results are to conform to tolerances established by recognized industry practice.
- H. Where, in the case of an otherwise satisfactory functional test, any doubt, dispute, or difference should arise between Engineer and Contractor regarding the test results or the methods or equipment used in the performance of such test, Engineer may order the test to be repeated.
- I. If the repeat test, using such modified methods or equipment as Engineer may require, confirms the previous test, all costs in connection with the repeat test will be paid by Owner. Otherwise, the costs are to be borne by Contractor.
- J. Where the results of any functional test fail to comply with the Project requirements for such test, then such repeat tests as may be necessary to achieve the project requirements shall be made by Contractor at his expense.
- K. Provide, at no expense to Owner, all power, fuel, compressed air supplies, water, and chemicals, all labor, temporary piping, heating, ventilating, and air conditioning for any areas where permanent facilities are not complete and operable at the time of functional tests, and all other items and work required to complete the functional tests. Temporary facilities are to be maintained until permanent systems are in service.

3.9 RETESTING

- A. While under test, any portion of the Work fails to fulfill the Project requirements and is adjusted, altered, renewed, or replaced, tests on that portion when so adjusted, altered, removed, or replaced, together with all other portions of the Work as are affected thereby, shall, unless otherwise directed by Engineer, be repeated within reasonable time and in accordance with the specified conditions.
- B. Pay to Owner all reasonable expenses incurred by Owner, including the costs of Engineer as a result of repeating such tests.

3.10 POST-TEST INSPECTION

- A. Once functional testing has been completed, recheck all machines for proper alignment and realigned, as required. Check all equipment for loose connections, unusual movement, or other indications of improper operating characteristics.
- B. Correct any deficiencies to the satisfaction of Engineer.
- C. All machines or devices which exhibit unusual or unacceptable operating characteristics are to be disassembled and inspected.
- D. Any defects found during the course of the inspection are to be repaired or the entire equipment item replaced to the complete satisfaction of Engineer at no cost to Owner.

3.11 OPERATIONAL TESTS

- A. After completion of all performance testing and certification by Engineer that all equipment complies with the requirements of the specifications, fill all process units and process systems, except those employing domestic water, oil, air, or chemicals, with plant effluent water.
- B. All domestic water, oil, air, and chemical systems are to be filled with the specified fluid.
- C. Upon completion of the filling operations, circulate water through the completed facility for a period of not less than 48 hours, during which all parts of the system shall be operated as a complete facility at various loading conditions, as directed by the Engineer.
- D. Commence operational testing period after this initial period of variable operation. The operational testing period shall be 60 days.
- E. Should the operational testing period be halted for any reason related to the facilities constructed or the equipment furnished under this project, or Contractor's temporary testing systems, the operational testing program shall be repeated until the specified continuous period has been accomplished without interruption.
- F. All process units are to be brought to full operating conditions, including temperature, pressure, and flow.

END OF SECTION