PART 1 - GENERAL

1.1 SUMMARY

A. Comply with the commissioning provisions specified in this Section and elsewhere in the Contract Documents.

B. General:

1. Unless noted otherwise, functional performance tests (FPT) apply to all equipment and systems identified to be tested in the Contract Documents.

2. Submittals shall be in accordance with Section 01 33 00 “Submittal Procedures” and for CAD (Computer Aided Drafting) Record Drawings, in accordance with Section 01 77 00 “Closeout Procedures.”

3. The duties of the Contractor’s “Test Engineer” and Owner’s “Commissioning Authority” are described in Section 01 75 00 “Test Engineer Services.”

4. The Contractor shall ensure that the Commissioning Authority, or other Owner-designated witness, is provided safe access to witness the performance of the equipment or systems being commissioned and is reasonably furnished ladders, scaffolding, and staging, if required, for witnessing.

1.2 COMMISSIONING DOCUMENTATION

A. Commissioning Plan: The Contractor shall prepare and submit a “Commissioning Plan” that identifies how commissioning activities will be integrated into the construction Progress Schedule and how commissioning responsibilities are distributed. Include, as a minimum, the following:

1. An organizational chart showing lines of communication and authority of the Test Engineer relative to key Contractor positions and to key Subcontractors

2. Who will be responsible for producing the various procedures, reports, Owner notifications, and forms required by the Contract Documents

3. A list of all control systems software required by the Contract Documents

4. The commissioning schedule

5. Commissioning forms and other documentation

6. Description of start-up and test procedures

7. A list of Subcontractors who will participate in each of the tests

8. The instrumentation required for each test and who will provide the instrumentation

9. Operational description for each test (This shall include, for example, the commissioning basis-of-design criteria provided by the commissioning authority, code requirements, the specifics of the equipment to be provided, sequences of operation, operating priorities, and other necessary information.)

10. One-line system and riser diagrams

B. Mechanical and Electrical Commissioning Binders (M&E): The M&E "Commissioning Binders" shall include the submittals, test equipment, commissioning procedures, installation verification audits, and FPT procedures documentation described in this Section.

1.3 SUBMITTALS

A. Start-up plans: Submit start-up plans, with start-up test procedures and documentation forms, for the equipment and systems for which a start-up is specified in the Contract Documents. Start-up plans shall include the following:

1. Start-up schedule
2. Names of firms/individuals required to participate
3. Detailed start-up procedures
4. Start-up forms
5. Operations and maintenance product data

B. Start-up installation verification audit report: Submit installation verification audit reports prior to start-up of equipment and systems for which a start-up is specified in the Contract Documents. Identify:

1. Equipment and/or systems, to be started-up;
2. Prestart-up tests performed, including manufacturer's factory tests;
3. Deficiencies noted;
4. Corrective action taken; and
5. Dates and initials of persons making the entries.

C. Start-up deficiency report form: Submit start-up deficiency report forms within five (5) days following the start-up of each equipment or system to report any deficiencies discovered in conjunction with start-up. Identify:

1. Equipment and/or systems started-up;
2. Location and identification of the deficient equipment and/or materials;
3. Date of observation and initials of observer;
4. Deficiencies noted;
5. Corrective action taken; and
6. Date of correction and initials of the person making the correction.

D. Test equipment identification list: Submit a list of all test equipment used in commissioning, sorted according to intended use. Provide an updated list, if any equipment is added to the commissioning, while testing is in progress. The list shall include the following information:

1. Manufacturer
2. Model number
3. Serial number
4. Date of most recent calibration
5. Range
6. Accuracy
7. Resolution
8. Intended use

E. Testing, Adjusting and Balancing (TAB) progress reports: Submit weekly TAB progress reports after TAB activities have begun. Identify the following:

1. Systems or subsystems for which preliminary balancing is complete
2. Systems or subsystems for which final balancing is complete
3. Status of deficiencies and balancing problems encountered, including corrective actions taken
4. Updated schedule of remaining TAB activities

F. FPT procedure documentation: Submit FPT procedure documentation for FPT specified in the Contract Documents. The documentation shall include the following:

1. FPT procedure description
2. Procedures that are based upon the actual equipment and/or systems configuration
3. The value for all set points and inputs, positions of adjustable devices, valves, dampers and switches
4. The acceptable test range for each FPT
5. Updated one-line system and riser diagrams
6. An alphanumeric designator for each procedure
7. Reference to the applicable Specifications section upon which the procedure is based

G. FPT data forms: Submit FPT data forms to document the equipment or systems FPT specified in the Contract Documents.

1. Identify each FPT data form by a unique designator, consisting of an applicable FPT procedure designator followed by a dash and digit suffix to distinguish multiple repetitions of the same procedure.

2. The FPT data form shall identify:

   a. Who needs to be in attendance for the tests, including but not limited to, Subcontractors, Commissioning Authority or other Owner-designated witness, regulatory agencies, and others as appropriate; and

   b. The sequence of the tests to be performed.

3. Include space to record the following:

    a. Description of the procedure
    b. Whether the form is for a retest of a failed procedure
    c. Identification and location of the equipment being tested
    d. Identification of instrumentation used, by type and serial number
    e. Observed conditions at each step of the procedure
    f. Acceptable results, as specified
    g. Date of the test
    h. Names of technicians performing the procedure
    i. Name and signature of the Contractor's Test Engineer
    j. Name and signature of the Commissioning Authority or Owner-designated witness

        (1) Signature of witness shall only indicate concurrence with reported results and observations. Acceptance of the results will be reported separately by the Commissioning Authority after review of the FPT data forms.

H. FPT deficiency report forms: Submit FPT deficiency report forms at the end of each day for all tests in which acceptable results were not achieved during the day. When corrections have been completed, update the FPT deficiency report form. FPT deficiency report forms shall record the following:

1. Associated FPT data form number and description
2. Equipment identification and location
3. Date of test
4. Name of person reporting the deficiency
5. Description of the observations associated with the failure of the test
6. Cause of the failure, if apparent at the time of the test
7. Date and description of corrective action take
8. Name and signature of person taking corrective action
9. Schedule for retest

I. One-line system and riser diagrams: Submit one-line system and riser diagrams with the Commissioning Plan, updated one-line system and riser diagrams with the FPT procedure documentation, and as-built one-line system and riser diagrams with the final M&E Commissioning Binders. One-line system and riser diagrams shall be submitted for the following, when included in the work of the Contract Documents:

1. Owner-provided one-line system and riser diagrams in CAD format for Contractor's use:
    a. Hot water heating
    b. Domestic water
    c. Steam and condensate
    d. Chilled water
    e. Condenser water
    f. Supply air

g. Return air
h. Exhaust air
i. Electrical normal and emergency power

2. Subcontractor-provided one-line system and riser diagrams CAD Shop Drawings, for Contractor's use:

a. Environmental control systems (ECS)
b. Fire alarm/smoke evacuation/life safety graphics and riser diagrams
c. Lighting control system diagrams
d. Electrical distribution equipment and spot or network substations schematic diagrams

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Provide industry standard test equipment required for performing the tests specified in the Contract Documents.

B. Instrumentation shall meet the following standards:

1. Be of sufficient quality and accuracy to test and measure system performance within the tolerances required to determine adequate performance

2. Be calibrated on the manufacturer's recommended intervals with calibration tags permanently affixed to the instrument being used

3. Be maintained in good repair and operational condition throughout the duration of use on this Project

4. Be recalibrated/repaired if dropped or damaged in any way since last calibrated

C. For all temperature measurements, including air, liquids, and surfaces of pipes and components, use appropriate probes that meet the following requirements:

1. Range: Minimum +14°F to 248°F
2. Type: Thermometer, digital electronic
3. Minimum accuracy: +/- 0.5°F
4. Calibration Interval: Per manufacturer instruction, not to exceed every twelve (12) months.

D. For hydronic systems pressure and differential pressure measurement instruments, the test equipment shall meet the following requirements:

1. Range: 0 to 30 psi (1 pound per square inch), 0 to 60 psi, and 0 to 200 psi
2. Type: Calibrated test gauges, 3 inch, or electronic digital device (TSI Performance Measurement Tools or similar) meeting accuracy and calibration interval requirements.
3. Minimum accuracy: 2% with a gauged scale; 3% with an electronic reading

4. Calibration interval: Per manufacturer's recommendation, not to exceed every twelve (12) months.
5. Note: Use lowest range instrument or scale

E. For air pressure measurement instruments, the test equipment shall meet the following requirements:

1. Range: 0 to 1 inch WC (water column), 0 to 4 inch WC, 0 to 10 inch WC
2. Type: Use properly leveled and zeroed manometer, magnehelic or electronic instrument meeting accuracy requirements
3. Minimum accuracy for electronic devices: 2% with a magnehelic reading; 3% with a electronic reading
4. Calibration interval for electronic devices: Per manufacturer's recommendation, not to exceed every twelve (12) months
5. Note: Use lowest range instrument or scale

F. Refer to electrical inspection, calibration, and testing requirements for instrumentation related to electrical systems and equipment.

PART 3 - EXECUTION

3.1 COMMISSIONING PROCEDURE

A. Sequence of testing: Commissioning shall proceed from lower to higher levels of complexity. For each system, testing at the lower level shall be completed prior to starting the next higher level of tests. In general, the order of testing, from lowest to highest is as follows:

1. Static tests (e.g., duct leakage tests)
2. Motors, actuators, sensors, and other system components requiring start-up and FPT
3. Point-to-point (PTP) testing
4. Balancing
5. System functional performance tests
6. Cross-systems functional performance tests

B. Retesting: Repeat, at no additional cost to the Owner, the complete functional test procedure for each test in which acceptable results are not achieved. Repeat tests until acceptable results are achieved. Fill out a new FPT data form for each retest.

C. Correction of deficiencies:

1. Correct FPT deficiencies promptly and schedule retest.

a. Corrections during FPT are generally prohibited to avoid consuming the time of personnel waiting for the test, but not involved in making the correction. Exceptions will be allowed if the cause of the failure is obvious and corrective action can be completed in less than five (5) minutes. If corrections are made under this exception, the failure shall be noted on the FPT data form. A new

FPT data form, marked “retest”, shall be submitted after the correction has been made. The entire FPT procedure shall be repeated.

3.2 INSTALLATION VERIFICATION AUDIT

A. Conduct an installation verification audit before equipment or system start-up begins. The audit shall include, but not be limited to, a check of the following equipment or systems:

1. Piping specialties, including balance, control, and isolation valves

2. Ductwork specialty items, including turning devices; balance, fire, smoke and control dampers; and access doors

3. Control sensors by type and locations

4. Piping, valves, starters, gauges, thermometers, and other components of the Work specified for formal start-up in the Contract Documents

5. Accessibility to equipment in 1 - 4 above

6. Verification of final programmed variable frequency drives (VFD) settings

B. If any part of the Work is found to be incomplete, inaccessible, incorrect, or non-functional, the Contractor shall make note of deficiencies, and correct deficiencies before system start-up work proceeds.

C. Coordinate with the electrical testing contractor (ETC) for the audit of electrical systems required by the Contract Documents.

3.3 TESTING, ADJUSTING, AND BALANCING (TAB)

A. Complete all PTP testing prior to start of TAB.

B. Coordinate and perform air and hydronic balancing. Advise the TAB firm when systems are complete and ready for balancing. Start TAB as early as possible following system start-ups and component FPT, in order to be essentially complete prior to system FPT. Coordinate TAB activities with other construction schedule activities.

C. Verify completion of PTP testing and the accuracy of the TAB work prior to commencing any FPT activities which may be adversely affected by incomplete PTP testing and improper balancing.

3.4 FUNCTIONAL PERFORMANCE TEST PROCEDURES

A. FPT procedures must confirm the performance of systems to the extent required by the Contract Documents.

1. Emphasis shall be placed on testing procedures which will conclusively determine actual system performance and compliance with the design.

B. FPT procedures shall demonstrate the actual performance of specified safety shut-offs in a real or closely simulated condition of failure. Failure conditions shall include adequate oil pressure, proof-of-flow, non-freezing conditions, maximum head pressure, and other conditions common to the equipment.

C. Systems may include safety devices and components that control a variety of equipment operating as a system. Interlocks may be hard-wired or installed via software. FPT procedures shall demonstrate these interlocks.

3.5 ECS SOFTWARE REVIEW

A. Review ECS software and required ECS cross-systems software routines prior to the installation of control devices. The review shall include:

1. Obtaining ECS program documentation
2. Review of the programming approach
3. Interface with other systems, including but not limited to:

   a. Lighting
   b. Fire alarm
   c. Security
   d. Clock
   e. Emergency generator monitoring
   f. Sump pumps
   g. Distributed and mechanical utility metering

B. Discrepancies in programming approaches shall be resolved with the Owner to provide the most appropriate, simple, and straightforward approach to software routines.

3.6 COMMISSIONING MEETINGS

A. The Contractor shall participate in the following meetings with the Commissioning Authority. Other Subcontractors may, at Owner's sole discretion, be required to attend as necessary.

1. Pre-commissioning kick-off meeting
2. Commissioning meetings described in Section 01 31 19 "Project Meetings"
3. ECS software review, and design intent clarification meeting
4. Preliminary O&M Manual review meeting

3.7 EQUIPMENT OPERATING INSTRUCTIONS AND TRAINING AGENDA

A. Each training session shall include an agenda addressing the following:

1. Introduction of presenters
2. Using the O&M information:

    a. What is the equipment
    b. Basic operating procedures (including start-up/shut-down)
    c. Preventative maintenance procedures
    d. Troubleshooting procedures

3. What does it do, or serve
4. Any special features
5. Safety precautions
6. Maintaining warranties, guarantees, and warranty periods
7. Instruction on how to use proprietary instrumentation or operating equipment
8. Recommended spares
9. Review of start-up reports and FPT results
10. Jobsite walk-through

END OF SECTION