

SECTION 23 08 00 – COMMISSIONING: GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Purpose

1. The purpose of the commissioning process is to provide the Owner assurance that the systems have been installed in the prescribed manner and will operate within the performance guidelines. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems to beneficial use by the Owner.
2. The Contractor verifies installation, provides scheduling and coordination of commissioning activities, performs training, starts up equipment, conducts functional performance testing, corrects deficiencies, performs retests, and provides documentation of the process.
3. The Commissioning Authority, hired directly by the Owner, provides the Owner an unbiased, objective view of the system's installation, documentation, operation, and performance.
4. Commissioning procedures and results will be observed by the Commissioning Authority. The Contractor is expected to verify the functional readiness of systems to be tested prior to performing the tests in the presence of the Commissioning Authority. A high rate of test failure will indicate that the Contractor has not adequately verified the readiness of the systems.

B. General

1. Furnish labor and material to accomplish building commissioning as specified herein.
2. Requirements of Commissioning Section shall be accomplished by a qualified Test Engineer, as specified in Division 01 Section "Test Engineer Services."
3. The requirement for and responsibilities of the Test Engineer are indicated in Division 01 Section "Test Engineer Services" and Commissioning Section.
4. The Commissioning Authority is an independent contractor and will work under a separate contract directly with the Owner.
5. Unless noted otherwise, functional performance tests (FPTs) described under "Acceptance Criteria" in the various sections of this division, apply to all equipment and systems identified under "Systems / Equipment to be Tested."

1.2 RELATED WORK

- ##### **A.**
- Refer to Division 23 Sections "Commissioning: Functional Performance Testing" and "Commissioning: Facility Start-up" for additional Contractor responsibilities relative to the commissioning process.

1.3 COORDINATION

- A. Provide overall coordination and management of the commissioning program as specified herein. The commissioning process will require cooperation of the Contractor, subcontractors, vendors, Commissioning Authority, and Owner. The commissioning team shall be comprised of the following:
 - 1. Contractor
 - a. Project Manager
 - b. Test Engineer
 - 2. Subcontractors
 - a. As required by the prime Contractor
 - 3. Commissioning Authority
 - a. Project Manager
 - b. Project Engineers
 - 4. Owner Representative(s) – Engineering Service, EH&S, Construction Coordinator, Design Services, etc.

1.4 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of the Contract and Division 01 Section “Submittal Procedures.”
- B. Commissioning Plan: Submit commissioning plan to the Owner’s Representative for review and approval by the Owner and Commissioning Authority within 90 calendar days of Notice to Proceed.
- C. Commissioning Schedule: Submit commissioning schedule to the Owner’s Representative for review and approval by the Owner and Commissioning Authority within 90 calendar days of Notice to Proceed.
- D. Start-up Plan: For each piece of equipment or system for which formal start-up is specified elsewhere in this division, submit a start-up plan to the Owner’s Representative for review and approval by the Owner and Commissioning Authority. Obtain approval of the plan prior to beginning -activities. The plan should include the following:
 - 1. Start-up schedule
 - 2. Names of firms/individuals required to participate
 - 3. Detailed start-up procedures
 - 4. Start-up data forms

- E. **Test Equipment Identification List:** For each instrument, sorted according to intended use, submit a list containing the following information to the Owner's Representative for review and approval by the Owner and Commissioning Authority:
 - 1. Manufacturer
 - 2. Model number
 - 3. Serial number
 - 4. Calibration certification
 - 5. Range
 - 6. Accuracy
 - 7. Resolution
 - 8. Intended use
- F. **Operations and Maintenance Manuals:** Submit to Owner's Representative prior to the start of training.
- G. **Start-up Procedures:** Submit start-up procedures for equipment for which formal start-up is specified elsewhere to the Owner's Representative for review and approval by the Owner and Commissioning Authority. These procedures will be reviewed for technical depth, clarity of documentation, and completeness.
- H. **Start-up Data Forms:** Submit start-up data forms for equipment for which formal start-up is specified elsewhere, to the Owner's Representative for review and approval by the Owner and Commissioning Authority.
- I. **Testing, Adjusting, and Balancing (TAB) Data Forms:** Submit testing, adjusting, and balancing (TAB) data forms to the Owner's Representative for review and approval by the Owner and Commissioning Authority.
- J. **Testing, Adjusting, and Balancing (TAB) Procedures:** Submit written testing, adjusting, and balancing (TAB) procedures to the Owner's Representative for review and approval by the Owner and Commissioning Authority.
- K. **Testing, Adjusting, and Balancing (TAB) Report:** Submit written testing, adjusting, and balancing (TAB) report to the Owner's Representative for review and approval by the Owner's Representative and Commissioning Authority.
- L. **Functional Performance Test Procedures:** Submit functional performance test procedures for functional performance tests specified elsewhere to the Owner's Representative for review and approval by the Owner and Commissioning Authority.
 - 1. Each procedure shall have a unique alphanumeric designator.
 - 2. The same procedure may be applied to multiple identical pieces of equipment or systems.
 - 3. Procedures shall reference the applicable specification section upon which the procedure is based.
 - 4. These procedures will be reviewed for technical depth, clarity of documentation, compliance with "Acceptance Criteria" specified elsewhere, and completeness.
 - 5. Identify the value for all setpoints and inputs, positions of adjustable devices, valves, dampers and switches.
 - 6. Identify the range of acceptable results for each condition tested.

7. FPT procedures shall be detailed test instructions, written with sufficient step-by-step information to allow a test to be repeated under identical conditions with repeatable results.
- M. Functional Performance Test Data Forms: Submit functional performance test data forms for equipment for which functional performance tests are specified elsewhere to the Owner's Representative for review and approval by the Owner and Commissioning Authority.
1. Identify each functional performance test data form by a unique designator, consisting of the applicable functional performance test procedure designator followed by a dash and digit suffix to distinguish multiple repetitions of the same procedure.
 2. 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 serial number
 - e. Observed conditions at each step of the procedure
 - f. "Acceptable results" as specified elsewhere
 - g. Date of the test
 - h. Names of technicians performing the procedure
 - i. Name and signature of the Test Engineer
 - j. Name and signature of the Commissioning Authority or Owner-designated witness. 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.
 3. The FPTs shall identify:
 - a. Who needs to be in attendance for the tests including subcontractors, owner, regulatory agencies, etc. and
 - b. The sequence of the tests to be performed.
 4. Draft FPTs shall be distributed to the Commissioning Authority, Owner, and EH&S and allow for a two week review period prior to scheduling any tests.
- N. Functional Performance Test Deficiency Report Forms: Submit functional performance test deficiency report forms to the Owner's Representative for review and approval by the Owner and Commissioning Authority. Include space to record the following:
1. Associated functional performance test data form number
 2. Date of test
 3. Name of person reporting the deficiency
 4. Description of the observations associated with the failure of the test
 5. Cause of the failure if apparent at the time of the test
 6. Date and description of corrective action taken
 7. Name and signature of person taking corrective action
 8. Schedule for retest

1.5 COMMISSIONING PLAN

- A. Develop a commissioning plan to identify how commissioning activities will be integrated into general construction and trade activities. The plan is the key means for the Test Engineer to inform all parties as to how each system functions, independently and with respect to other systems. The plan shall be updated regularly and redistributed to the commissioning team for review and comment. The intent of this plan is to evoke questions, expose issues, and resolve them with input from the entire commissioning team early in construction. The commissioning plan shall identify how commissioning responsibilities are distributed.
 - 1. Include an organizational chart showing lines of communication and authority of the Test Engineer relative to key General Contractor positions and to key subcontractors.
 - 2. Identify who will be responsible for producing the various procedures, reports, Owner notifications, and forms required in this division.
 - 3. Include the commissioning schedule.
 - 4. Describe the test/acceptance procedure.
 - 5. Identify which subcontractors will participate in each of the tests.
 - 6. Identify instrumentation required for each test.
 - 7. Identify who will provide instrumentation for each test.
 - 8. Operational description: This shall include, for example, the design criteria, design intent, code requirements, specifics of the equipment to be provided, sequences of operation, operating priorities, protocols, etc.

1.6 SCHEDULE

- A. Integrate functional performance testing and commissioning requirements into the Critical Path Method (CPM) master construction schedule. Commissioning scheduling is the responsibility of the Contractor.
- B. Commissioning of systems shall proceed per the criteria established in the specific sections that follow, with activities to be performed on a timely basis. Commissioning of systems may proceed prior to final completion of systems. The Test Engineer must be available to respond promptly to avoid delay to the CPM schedule.
- C. Problems observed shall be addressed immediately, in terms of notification to responsible parties and actions to correct deficiencies.

1.7 COORDINATION WITH COMMISSIONING AUTHORITY

- A. The Commissioning Authority will witness all start-up and test activities specified in this division. The Owner's Representative will designate witnesses and alternates for each activity.
- B. Notify the Owner's Representative in writing of the date, time, location, and anticipated duration of start-up and test activities as required in Article "Schedule" above.
- C. Provide written timely notice to Owner's Representative of any changes in date, time, location, or anticipated duration of start-up and test activities. For the purpose of this paragraph, written notice shall be received by Owner's Representative a minimum of 72 hours in advance to be considered timely notice.

- D. Contractor shall reimburse Owner for actual costs incurred by the Owner as the result of failure to provide timely notice, per preceding paragraph, of changes in date, time, location, or anticipated duration of start-up and test activities.
- E. Obtain the signature of designated witness on all data forms. If the witness is unavailable at the scheduled time and location of the activity, so note, and proceed per schedule without the witness.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. Provide industry standard test equipment required for performing the tests specified herein.
- 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 operation condition throughout the duration of use on this project.
 - 4. Be recalibrated/repared if dropped or damaged in any way since last calibrated.
- C. For all temperature measurements including air, liquids, and surfaces of pipes and components using appropriate probes:
 - 1. Range: Minimum plus 14 deg F to 248 deg F
 - a. Type: Thermometer, Digital Electronic
 - b. Minimum accuracy: Plus or minus 0.5 deg F
 - c. Calibration Interval: Per manufacturer instruction, not to exceed every 12 months
- D. For hydronic pressure and differential pressure measurement instruments:
 - 1. Range: 0 to 30 psi, 0 to 60 psi and 0 to 200 psi
 - a. Type: Calibrated Test Gauges, 3 inch, or electronic digital device (TSI or similar) meeting accuracy and calibration interval requirements
 - b. Minimum accuracy: 2 percent of scale (gauge), 3 percent of reading (electronic)
 - c. Calibration interval: Per manufacturers instruction, not to exceed every 12 months
 - d. Note: Use lowest range instrument or scale.
- E. Air pressure measurement instruments:
 - 1. Range: 0 to 1 inch w.c., 0 to 4 inch w.c., 0 to 10 inch w.c.
 - a. Type: Use properly leveled and zeroed manometer, Magnehelic or electronic instrument meeting accuracy requirements.

- b. Minimum accuracy for electronic devices: 2 percent of reading (Magnehelic), 3 percent of reading (electronic)
 - c. Calibration Interval for electronic devices: Per manufacturer's instructions, not to exceed every 12 months
 - d. Note: Use lowest range instrument or scale.
- F. Provide a list of all test equipment used in commissioning. Show manufacturer, model number, serial number and date of most recent calibration. Provide an updated report if any instruments are added to the commissioning while the testing is in progress.

2.2 REPORTS

- A. Test, Adjust and Balance (TAB) Progress Reports: After TAB activities have begun, submit weekly test, adjust and balance (TAB) progress reports to the Owner's Representative. 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
- B. Installation Verification Audit: Prior to start-up, submit to the Owner's Representative for review and approval by the Owner and Commissioning Authority a report of installation verification audit activities. Identify equipment and components verified, deficiencies noted, corrective action taken, and the dates and initials of the persons making the entries.
- C. Start-up Deficiency Report: Within five days following start-up of each system or equipment, submit to the Owner's Representative start-up deficiency report forms. Identify systems and/or equipment started up, deficiencies noted, corrective action taken, and the dates and initials of the persons making the entries.
- D. Functional Performance Test Deficiency Reports: At the end of each day in which functional performance tests are conducted, submit to the Owner's Representative functional performance test deficiency report forms for tests in which acceptable results were not achieved during the day.
 - 1. Identify tests for which acceptable results were not obtained by test number and description, and equipment identification and location. Briefly describe observations about the performance which were associated with failure to achieve acceptable results. Identify the cause of failure if such is apparent.
 - 2. When corrections have been completed, update the functional performance test deficiency report forms. Identify corrective action taken and the dates and initials of the persons making the entries.
 - 3. Identify the schedule for retesting.

PART 3 - EXECUTION

3.1 BASIS OF DESIGN DOCUMENTATION

- A. Edit and update basis of design narratives provided by the Owner's Representative (Consultant). Incorporate the effect of approved substitution requests, change orders, and responses to RFCs which change the information in the basis of design narratives. "Basis of Design" includes design criteria and operations descriptions for systems itemized in Article "One-Line Diagrams."
- B. Design criteria shall include design conditions for each space as follows:
 - 1. Indoor dry bulb temperature
 - 2. Indoor relative humidity
 - 3. Outdoor dry bulb temperature
 - 4. Outdoor wet bulb temperature
 - 5. Occupancy, hours, and degree of activity
 - 6. Lighting and miscellaneous power
 - 7. Ventilation -- recirculation and outside air
 - 8. Internal loads
 - 9. Special loads
 - 10. Insulating R-values for roof, wall, glass, etc.
 - 11. Percentage of glass -- fenestration
 - 12. Type of glass, including coatings and solar coefficients
 - 13. Building pressurization and infiltration
 - 14. Building mass
 - 15. Code requirements and impact on criteria
 - 16. Air quality design criteria, i.e. ASHRAE 62.1-2004
 - 17. Noise criteria
 - 18. Fire and life safety
 - 19. Energy efficiency and cost
 - 20. Maintainability
- C. Operations description includes design intent, basic system type, major components, interrelation of components, capacity and sizing criteria, redundancy, diversity, automatic temperature control and sequence of operation, intended operation under all seasonal loads, changeover procedures, part-load strategies, occupied/unoccupied modes of operation, design setpoints of control systems with permissible adjustments, operation of system components in life-safety modes, energy conservation procedures, and any other engineered operational mode of the systems.

3.2 ONE-LINE DIAGRAMS

- A. Provide one-line diagrams: One-line diagrams are intended to support narrative system descriptions and the overall commissioning process. Depending on the system in question, the following procedures for developing the one-line diagrams are to be employed:

1. Update: AutoCAD-based one-line diagrams for the following systems. Some revisions may be required to match the desired format for commissioning documents.
 - a. Hot Water Heating
 - b. Domestic Water
 - c. Steam and Condensate
 - d. Chilled Water Systems
 - e. Condenser Water Systems
 - f. Supply Air Systems
 - g. Return Air Systems
 - h. Exhaust Air Systems
2. Update and revise vendor supplied AutoCAD-based shop drawings; revise as required to match the format for commissioning documents. This method shall be employed for the following systems:
 - a. Environmental Control System
 - b. Energy Management Control
 - c. Fire Alarm/Smoke Evacuation/Life Safety Graphics

3.3 COMMISSIONING PROCEDURE

- A. Sequence of Testing: Commissioning shall proceed from lower to higher levels of complexity. For each discrete subsystem or 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. Component functional performance tests (i.e. motors, actuators and sensors) and start-up
 3. Balancing
 4. System functional performance tests
 5. Intersystem 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. Compensate the Owner for direct costs incurred as the result of tests repeated to achieve acceptable results. Fill out a new functional performance test data form for each retest.
- C. Correction of Deficiencies:
 1. Correct functional performance test deficiencies promptly and schedule retest.
 2. Corrections during functional performance tests 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 minutes. If corrections are made under this exception, the failure shall be noted on the functional performance test data form. A new functional performance test data form, marked "retest," shall be initiated after the correction has been made. The entire functional performance test procedure shall be repeated.

- D. Owner Witness: Commissioning Authority will provide no labor or materials in the commissioning process. The only function of the Commissioning Authority shall be to observe and comment on the progress and results of commissioning.
1. Provide access to permit the Commissioning Authority to directly observe the performance of the equipment being tested.
 2. Provide ladders, scaffolding, and staging as required to permit the Commissioning Authority to directly observe the performance of the equipment being tested.
 3. Notify the Owner's Representative of commissioning schedule changes at least 48 hours in advance if a Commissioning Authority will be involved.

3.4 INSTALLATION VERIFICATION

- A. During construction, observe the work of the prime Contractor and subcontractors to assure that all installations are being made in accordance with the intent of the contract documents.
- B. Before system start-up begins, conduct a final installation verification audit. The Contractor shall be responsible for completion of all work, including change orders and punch list items, to the satisfaction of the Owner's Representative. The audit shall include, but not be limited to, a check of the following:
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 sensor types and locations
 4. Identification of piping, valves, starters, gauges, thermometers, etc.
 5. Documentation of prestart-up tests performed, including manufacturer's factory tests
 6. Accessibility to equipment in subparagraphs 1 to 3 above
 7. Verification of final programmed VFD settings.
- C. If any work is found to be incomplete, inaccessible, incorrect, or non-functional, make note of deficiencies, and correct deficiencies before system start-up work proceeds.

3.5 SYSTEM START-UP

- A. Develop a start-up plan. Commence with system start-up after approval has been given to the start-up plan and the pre-start-up inspection has been completed by the Test Engineer. The Test Engineer shall witness system start-up and list all system and equipment deficiencies noted during start-up. The Contractor shall take corrective action on all system deficiencies noted and demonstrate to the Test Engineer suitable system operation. Notify Owner's Representative of start-up activities' schedule at least five working days in advance. Owner's Representative and Commissioning Authority will physically witness start-up procedures. Test Engineer shall obtain signature of the Owner's Representative and Commissioning Authority indicating successful start-up.

3.6 START-UP DEFICIENCY LISTS

- A. Prepare Start-up Deficiency List forms to report deficiencies discovered in conjunction with system start-up. Start-up deficiency forms shall indicate the system being started-up, the location and identification of the deficient equipment/material, date of observation; initials of the observer; observed deficiency; date of correction; initials of person making the correction; and corrective action taken.
- B. Issue Start-up Deficiency Report Forms to the Contractor for corrective action, and to the Owner's Representative for follow-up. The Contractor shall advise the Test Engineer and Owner's Representative when all start-up deficiency list items have been corrected.
- C. Complete all point-to-point testing prior to start of Test, Adjust and Balance (TAB).

3.7 TEST, ADJUST, AND BALANCE (TAB)

- A. Perform and coordinate 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 functional performance tests, in order to be essentially complete prior to system functional performance tests. Coordinate TAB activities with other construction schedule activities.
- B. Verify the accuracy of the TAB work prior to commencing any FPT activities which may be adversely affected by improper balancing.

3.8 FUNCTIONAL PERFORMANCE TEST PROCEDURES

- A. Develop start-up procedures and functional performance test procedures and documentation to be used. Personnel experienced in the technical aspects of each system to be commissioned shall be engaged if necessary to augment the expertise of the Test Engineer. Include functional performance test procedures and functional performance test data sheets for each system based upon actual system's configuration. Emphasis shall be placed on testing procedures which will conclusively determine actual system performance and compliance with the design.
- B. Test procedures shall fully describe system configuration and steps required for each test, appropriately documented so that another party can repeat the tests with virtually identical results.
- C. Acceptance test procedures must confirm the performance of systems to the extent of the design intent and applicable code under which the project was permitted. When a system is accepted, the Commissioning Authority must be assured that the system is complete, works as intended, is correctly documented, and that the Owner's staff is trained in the operation and maintenance of the system.
- D. The majority of mechanical equipment requires integral safety devices to stop/prevent equipment operation unless minimum safety standards or conditions are met. This could include adequate oil pressure, proof-of-flow, non-freezing conditions, maximum head pressure, etc. Functional performance test procedures shall demonstrate the actual performance of safety shutoffs in a real or closely simulated condition of failure.

- E. 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. Functional performance test procedures shall demonstrate these interlocks.
- F. Inform appropriate subcontractor(s) and vendor(s) before commissioning is started as to what the test and expected results will be. Because some test results and interpretations may not become evident until the actual tests are performed, all participants should have a reasonable understanding of the requirements. The commissioning plan must address the requirements and be distributed to all participants involved with that particular system.

3.9 REVIEW SOFTWARE DOCUMENTATION

- A. Review, prior to installation of control devices, vendor/contractor-provided detailed BAS software documentation. This includes obtaining BAS program documentation, a review of the programming approach, interface with other systems (e.g. lighting, fire alarm, security, clock, emergency generator monitoring, sump pumps, and utility metering), and a review of the specific software routines as applied to this project. Discrepancies in programming approaches will be resolved to provide the Owner with the most appropriate, simple, and straightforward approach to software routines.
- B. Provide copies of all of the preceding material, including electronic copies of all control system software to the Owner's Representative, so that Owner's technical staff can simulate system operation and troubleshoot the software.

3.10 TRAINING

- A. Prepare and submit for approval a training plan. Training plan shall include for each training session the following:
 - 1. Dates, start and finish times, and locations
 - 2. Outline of the information to be presented
 - 3. Names and qualifications of the presenters
 - 4. List of texts and other materials required to support training
- B. Obtain assistance from appropriate subcontractors and vendors to provide training for the Owner's operations staff.
- C. Provide videotape documentation of training of the Owner's staff for each system. Training will be in a classroom setting with the appropriate schematics, handouts, and audio/visual training aids.
- D. Catalog training videotapes and deliver to the Owner's Representative with the O&M manuals.
- E. Host each training session:
 - 1. Provide program overview and curriculum guidance.
 - 2. Obtain signatures of attendees on a sign-in list.

- F. Equipment vendors provide training on the specifics of each system and philosophy, troubleshooting, and repair techniques as specified in the relevant sections of this specification.
- G. Installation subcontractors provide training on peculiarities specific to this project and job specific experience as specified in the relevant sections of this specification.
- H. Review record documents to verify accuracy.

3.11 FUNCTIONAL COMPLETION

- A. The Commissioning Authority will review Contractor's records of completion of Commissioning requirements. Upon receiving evidence of satisfactory completion of Functional Completion requirements in Division 01 Section "Commissioning", the Test Engineer will submit to the Owner's Representative a recommendation to accept Functional Completion.

3.12 EXCLUSIONS

- A. The Owner's Representative and Commissioning Authority are not responsible for construction means, methods, job safety, or any management function related to commissioning on the job site.
- B. The Contractor shall provide all technician services requiring tools or the use of tools, to test, adjust or otherwise bring equipment into a full operational state.

END OF SECTION 23 08 00