

PART 1 – GENERAL

1.1 DESCRIPTION

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 or Owner's Construction Representative, 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 reviewed and 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. The requirement for and responsibilities of the Test Engineer are indicated in Division 01 and Commissioning Section.
3. The Commissioning Authority is an independent contractor and will work under a separate contract directly with the Owner. The responsibilities of the Commissioning Authority are indicated, for information only, in Division 01.
4. 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 SPECIFIED ELSEWHERE

A. Related Sections:

1. Division 23.

1.3 CODES AND STANDARDS

- #### A. Codes and Standards shall be the current version adopted by the Authority Having Jurisdiction.

1.4 COORDINATION

- #### A. The General Contractor and the Test Engineer shall provide overall coordination and management of the commissioning program as specified herein. The commissioning process

will require cooperation of the Contractor, subcontractors, vendors, Architect, Mechanical Engineer, Electrical Engineer, Test Engineer, Commissioning Authority, and Owner

1.5 SUBMITTALS

- A. General: The Test Engineer shall submit the following with input from the Contractors, Sub-Contractors, and Vendors:
- B. Commissioning plan: Submit (6) copies of a draft commissioning plan to the Owner's Representative for review and approval by the Architect and Commissioning Authority within 90 calendar days of Notice to Proceed. Submit (6) copies of the commissioning plan to the Owner's Representative after all review comments have been incorporated from the Architect and the Commissioning Authority. 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 a summary of all commissioning tests to be performed.
 - 4. Include the commissioning schedule.
 - 5. Describe the test/acceptance procedure.
 - 6. Identify which subcontractors will participate in each of the tests.
 - 7. Identify instrumentation required for each test.
 - 8. Identify who will provide instrumentation for each test.
- C. Commissioning schedule: Submit (6) copies of a draft commissioning schedule to the Owner's Representative for review and approval by the Architect and Commissioning Authority within 90 calendar days of Notice to Proceed.
 - 1. Integrate functional performance testing and commissioning requirements into the Critical Path Method (CPM) master construction schedule. Commissioning scheduling is the responsibility of the Contractor. The schedule shall include dates for commissioning testing of each system and shall also include startup prerequisite activities shown linked to specific functional performance testing dates.
 - 2. 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.
 - 3. The commissioning schedule shall incorporate the completion of all commissioning testing, with the exception of retesting resulting from deficiencies and seasonal testing, before the Final Certificate of Occupancy date.
 - 4. Problems observed shall be addressed immediately, in terms of notification to responsible parties and actions to correct deficiencies.
- 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 Architect and Commissioning Authority. Submit (6) copies of the draft startup plan. Submit (6) copies of the startup plan after all review comments have been incorporated from the Architect and Commissioning Authority. Obtain approval of the plan prior to beginning startup activities. The plan shall include the following:
1. Start-up schedule
 2. Names of firms/individuals required to participate
 3. Detailed start-up procedures (may be manufacturer's startup checklist and procedures)
 4. Start-up data forms
- E. Test equipment identification list: For each instrument, sorted according to intended use, submit (6) copies of a list containing the following information to the Owner's Representative for review and approval by the Architect and Commissioning Authority. Submit (6) copies of the list to the Owner's Representative after all comments have been incorporated from the Architect and the Commissioning Authority:
1. Manufacturer
 2. Model number
 3. Serial number
 4. Calibration certification
 5. Range
 6. Accuracy
 7. Resolution
 8. Intended use
- F. Testing, Adjusting, and Balancing (TAB) data forms: In addition to the requirements for TAB submittals in other sections of this specification, submit (6) copies of the testing, adjusting, and balancing (TAB) data forms to the Owner's Representative for review and approval by the Architect and Commissioning Authority. Submit (6) copies of the TAB forms after all comments have been incorporated from the Architect and the Commissioning Authority. Forms shall be approved prior to the start of TAB activities.
- G. Testing, Adjusting, and Balancing (TAB) report: In addition to the requirements for TAB report submittals in other sections of this specification, submit (1) additional copy for review and approval by the Commissioning Authority. A preliminary TAB report shall be submitted first for approval. A final TAB report shall be submitted to incorporate review comments or, if additional TAB work is identified by the preliminary review comments, after the additional TAB work is completed.
- H. Functional performance test procedures: Refer to Section 23 08 13 for additional requirements for functional performance test procedures. Submit functional performance test procedures for functional performance tests to the Owner's Representative for review and approval by the Architect 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. 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.

- I. Functional performance test procedures: Submit (6) copies of the draft functional performance test procedures/data forms to the Owner's Representative for review and approval by the Architect 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. Observed conditions at each step of the procedure
 - e. Date of the test
 - f. Names and company of technicians performing the procedure
 - g. Name and signature of the Test Engineer
 - h. 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. Functional performance test procedures and functional performance test data sheets for each system shall be based upon actual system's configuration.
 4. 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.
 5. 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.
 6. 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.
 7. 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.
 8. 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.
- J. Functional performance test deficiency report forms: Submit sample functional performance test deficiency report forms to the Owner's Representative for review and approval by the Architect 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
- K. Owner Training Plan: Prepare and submit (6) copies of a training plan to the Owner's Representative for review and approval by the Architect and Commissioning Authority.
1. Training plan shall include for each training session the following:
 - a. Dates, start and finish times, and locations
 - b. Outline of the information to be presented
 - c. Names and qualifications of the presenters
 - d. List of texts and other materials required to support training
 2. Obtain assistance from appropriate subcontractors and vendors to provide training for the Owner's operations staff.
 3. Training will be in a classroom setting with the appropriate schematics, handouts, and audio/visual training aids.
 4. Catalog training videotapes and deliver to the Owner with the O&M manuals.
 5. Host each training session:
 - a. Provide program overview and curriculum guidance.
 - b. Obtain signatures of attendees on a sign-in list.
 6. 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.
 7. Installation subcontractors provide training on peculiarities specific to this project and job specific experience as specified in the relevant sections of this specification.
 8. Review record documents to verify accuracy.

1.6 COORDINATION WITH COMMISSIONING AUTHORITY

- A. The Commissioning Authority will witness 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 "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. 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.
- B. For all temperature measurements including air, liquids, and surfaces of pipes and components using appropriate probes:
 - 1. Range: Minimum +15 ° F to 230° F
 - a. Type: Thermometer, Digital Electronic
 - b. Minimum accuracy: +/- 0.5° F
 - c. Calibration Interval: Per manufacturer instruction, not to exceed every 12 months
- C. 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, 6 inch, or electronic digital device (Shortridge, Alnor, or equal) meeting accuracy and calibration interval requirements
 - b. Minimum accuracy: 2% of scale (Gauge), 1% of reading (electronic)
 - c. Calibration interval: Per manufacturers instruction, not to exceed every 12 months
 - d. Note: Use lowest range instrument or scale.
- D. 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% of reading (Magnehelic or manometer), 1% 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.

2.2 REPORTS

- A. Installation verification audit: Prior to start-up, submit to the Owner's Representative for review and approval by the Architect 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.

1. 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.
 2. 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:
 - a. Piping specialties, including balance, control, and isolation valves
 - b. Ductwork specialty items, including turning devices; balance, fire, smoke and control dampers; and access doors
 - c. Control sensor types and locations
 - d. Identification of piping, valves, starters, gauges, thermometers, etc.
 - e. Documentation of prestart-up tests performed, including manufacturer's factory tests
 - f. Accessibility to equipment in 1-3 above
- B. 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.
- C. Functional performance test deficiency reports: Submit weekly functional performance tests deficiency reports to the Owner's Representative.
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.
- D. Final Commissioning Reports: Submit (6) copies of the draft final commissioning report to the Owner's Representative for review and approval by the Architect and the Commissioning Authority. The draft final commissioning report shall be submitted a minimum of two weeks prior to the Final Certificate of Occupancy date. The draft final commissioning report shall include completed commissioning functional performance test procedures for all identified systems to be commissioned. For those systems that require re-testing due to deficiencies found during initial functional testing and those tests that require seasonal conditions to complete (i.e. – heating and cooling coil capacity tests), the initial completed functional test procedure shall be included in the preliminary final commissioning report. After all re-testing and seasonal testing has been completed, submit (6) copies of the final commissioning report to the Owner's Representative including the documentation for all re-testing and seasonal testing. The final commissioning report shall include the following items:
1. An executive summary including a brief description of the project, the commissioning process, and the results of the commissioning process.
 2. A list of all outstanding items that were not resolved through the commissioning process.
 3. Recommendations for system improvements that were not implemented through the commissioning process.

4. Log, list, or matrix of all deficiencies encountered during the course of functional performance testing.
5. All meeting notes.
6. All installation verification audits.
7. All startup deficiency reports.
8. All completed functional test procedures and data forms.

PART 3 – EXECUTION

3.1 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. System startup static tests (e.g. duct leakage tests, pipe static pressure tests)
 2. Contractor equipment startup and vendor equipment startup including unitary controls checkout
 3. Controls startup and initial checkout (Point-to-Point testing)
 4. Testing, Adjusting, and Balancing (TAB)
 5. System functional performance tests (FPT)
 6. 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 shall 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 Agent to directly observe the performance of the equipment being tested.
 2. Provide ladders, scaffolding, and staging as required to permit the Commissioning Agent 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 Agent will be involved.

3.2 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, the Commissioning Authority will submit to the Owner a recommendation to accept Functional Completion.

3.3 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