23 08 00 – Commissioning Requirements for HVAC

DIVISION 23 – Heating, Ventilating, and Air Conditioning

OUTLINE SPECIFICATION

STATEMENT OF PURPOSE & BACKGROUND

- Scope:
  - This section contains the specific objectives and the Contractor's responsibilities for commissioning building systems prior to startup.
  - The scope of Commissioning is detailed in the section below.
- Revision history of section:
  - 08/14/2018 (date of adoption)
  - 02/25/2019
  - 10/28/2022

PART 1 GENERAL

1.1 SUMMARY

A. Commissioning is intended to achieve the following specific objectives.
   a. Define, document and maintain a clearly stated set of measurable system performance requirements throughout the design and construction of the project.
   b. Verify and document compliance with these requirements at each completion milestone.
   c. Establish a clear set of tasks, deliverables, and schedule milestones for every member of the commissioning team to drive building delivery to a successful conclusion;
   d. Demonstrate and document effective integrated buildings performance through a rigorous process of system testing;
   e. Verify that operation and maintenance personnel and occupants are properly trained;
   f. Provide documentation, training tools, and building performance metrics that will allow SPPS to sustain building systems over the life of the building.

B. This section specifies the Contractor's responsibilities for commissioning building systems prior to startup.

C. The Commissioning Authority directs and coordinates all commissioning activities. This section describes some but not all of the Commissioning Authority's responsibilities.

D. The Commissioning Authority is employed by the Owner on behalf of the Owner.

E. Verify that the work is installed in accordance with the Contract Documents and the manufacturer's recommendations and instructions, and that it receives adequate operational checkout prior to startup. Startup reports and Pre-functional Checklists executed by Contractor are utilized to achieve this.

F. Verify and document that functional performance is in accordance with the Contract Documents. Functional Tests executed by Contractor and witnessed by the Commissioning Authority shall be utilized to achieve this.

G. Verify that operation and maintenance manuals submitted to Owner are complete. Detailed operation and maintenance (O&M) data submittals by Contractor shall be utilized to achieve this.

H. Verify that the Owner's operating personnel are adequately trained: Formal training conducted by Contractor shall be utilized to achieve this.

1.2 SCOPE OF COMMISSIONING

A. The following are to be commissioned:

B. HVAC System, including:
   1. Air handling units
   2. Make-up air units
   3. Fans
   4. Boilers
   5. Pumps
   6. Condensing units
   7. Energy recovery units
   8. Unit heaters
   9. VAV boxes and coils
   10. Finned-tube radiation
   11. Variable frequency drives.
   12. Piping systems
   13. Ductwork and accessories
   14. Automatic controls and building automation system

C. Communications: Verify with Owner.

D. Other equipment and systems explicitly identified elsewhere in Contract Documents as requiring commissioning.

1.3 REFERENCE STANDARDS

A. CSI/CSC MF - Masterformat; 2016.

B. PECI (Samples) - Sample Forms for Pre-functional Checklists and Functional Performance Tests; current edition.

1.4 SUBMITTALS

A. Administrative Requirements
   1. Make all submittals specified in this section, and elsewhere where indicated for commissioning purposes, directly to the Commissioning Authority, unless they require review by Architect; in that case, submit to Architect first.
   2. Submit one copy to the Commissioning Authority, not to be returned.
   3. Make commissioning submittals on time schedule specified by Commissioning Authority.
   4. Submittals indicated as "Draft" are intended for the use of the Commissioning Authority in preparation of Pre-functional Checklists or Functional Test requirements; submit in editable electronic format, Microsoft Word 2020 preferred.
   5. As soon as possible after submittals made to Architect are approved, submit copy of approved submittal to the Commissioning Authority.

B. Product Data: If submittals to Architect do not include the following, submit copies as soon as possible:
   1. Manufacturer's product data, cut sheets, and shop drawings.
   2. Manufacturer's installation instructions.
   3. Startup, operating, and troubleshooting procedures.
   4. Fan and pump curves.
   5. Factory test reports.
   6. Warranty information, including details of Owner's responsibilities in regard to keeping warranties in force.

C. Manufacturers' Instructions: Submit copies of all manufacturer-provided instructions that are shipped with the equipment as soon as the equipment is delivered.

D. Startup Plans and Reports.

E. Completed Pre-functional Checklists.

PART 2 PRODUCTS

2.1 TEST EQUIPMENT

A. Provide all standard testing equipment required to perform startup and initial checkout and required Functional Testing; unless otherwise noted such testing equipment will NOT become the property of Owner.

B. Calibration Tolerances: Provide testing equipment of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:
   1. Temperature Sensors and Digital Thermometers: Certified calibration within past year to accuracy of 0.5 degree F and resolution of plus/minus 0.1 degree F.
   2. Pressure Sensors: Accuracy of plus/minus 2.0 percent of the value range being measured (not full range of meter), calibrated within the last year.
   3. Calibration: According to the manufacturer's recommended intervals and when dropped or damaged; affix calibration tags or keep certificates readily available for inspection.

C. Equipment-Specific Tools: Where special testing equipment, tools and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to Owner; such equipment, tools, and instruments are to become the property of Owner.

D. Data loggers: Independent equipment and software for monitoring flows, currents, status, pressures, etc. of equipment.
   1. Data loggers required for Functional Tests will be provided by the Commissioning Authority and will not become the property of Owner.

PART 3 EXECUTION

3.1 COMMISSIONING PLAN

A. Commissioning Plan preparation is the responsibility of the Commissioning Authority.
   1. Attend meetings called by the Commissioning Authority for purposes of completing the commissioning plan.
   2. Require attendance and participation of relevant subcontractors, installers, suppliers, and manufacturer representatives.

B. Contractor is responsible for compliance with the Commissioning Plan.

C. Commissioning Plan: The plan is comprised of the commissioning schedule, procedures, and coordination requirements for all parties in the commissioning process.
   1. Commissioning will be phased (by floors, for example) to minimize the total construction time.

D. Basis of Design Documentation (BOD): The BOD is comprised of detailed documentation of the functional requirements of the project and descriptions of the systems, components, and methods chosen to meet the design intent, as well as documentation of the assumptions underlying the design intent.
   1. Basis of Design Documentation is to be prepared by Architect.

E. Commissioning Schedule:
   1. Submit anticipated dates of startup of each item of equipment and system to Commissioning Authority within 60 days after award of Contract.
   2. Re-submit anticipated startup dates monthly, but not less than 4 weeks prior to startup.
   3. Pre-functional Checklists and Functional Tests are to be performed in sequence from components, to subsystems, to systems.

4. Provide sufficient notice to Commissioning Authority for delivery of relevant Checklists and Functional Test procedures, to avoid delay.

3.2 DOCUMENTATION IDENTIFICATION SYSTEM

A. Give each submitted form or report a unique identification; use the following scheme.

B. Type of Document: Use the following prefixes:
   1. Startup Plan: SP-.
   2. Startup Report: SR-.
   3. Pre-functional Checklist: PC-.
   4. Functional Test Procedure: FTP-.
   5. Functional Test Report: FTR-.

C. System Type: Use the first 4 digits from CSI/CSC MF (Master Format), that are applicable to the system; for example:
   1. 2300: HVAC system as a whole.
   2. 2320: HVAC Piping and Pumps.
   3. 2330: HVAC Air Distribution.

D. Component Number: Assign numbers sequentially, using 1, 2, or 3 digits as required to accommodate the number of units in the system.

E. Test, Revision, or Submittal Number: Number each successive iteration sequentially, starting with 1.

F. Example: PC-2320-001.2 would be the Pre-functional Checklist for equipment item 1 in the HVAC piping system, probably a pump; this is the second, revised submittal of this checklist.

3.3 STARTUP PLANS AND REPORTS

A. Startup Plans: For each item of equipment and system for which the manufacturer provides a startup plan, submit the plan not less than 8 weeks prior to startup.

B. Startup Reports: For each item of equipment and system for which the manufacturer provides a startup checklist (or startup plan or field checkout sheet), document compliance by submitting the completed startup checklist prior to startup, signed and dated by responsible entity.

C. Submit directly to the Commissioning Authority.

3.4 PRE-FUNCTIONAL CHECKLISTS

A. A Pre-functional Checklist is required to be filled out for each item of equipment or other assembly specified to be commissioned.
   1. No sampling of identical or near-identical items is allowed.
   2. These checklists do not replace manufacturers' recommended startup checklists, regardless of apparent redundancy.
   3. Pre-functional Checklist forms will not be complete until after award of the contract; the following types of information will be gathered via the completed Checklist forms:
      a. Certification by installing contractor that the unit is properly installed, started up, and operating and ready for Functional Testing.
      b. Confirmation of receipt of each shop drawing and commissioning submittal specified, itemized by unit.
      c. Manufacturer, model number, and relevant capacity information; list information "as specified," "as submitted," and "as installed."
      d. Serial number of installed unit.
      e. List of inspections to be conducted to document proper installation prior to startup and Functional Testing; these will be primarily static inspections and procedures; for equipment and systems may include normal manufacturer’s start-up checklist items and minor testing.
      f. Sensor and actuator calibration information.

4. All preliminary Pre-functional Checklists are included in the contract documents; the Commissioning Authority has the authority to modify these and will furnish final versions as applicable.
5. A preliminary list of Pre-functional Checklists is attached, to indicate anticipated scope.
6. PECI (Samples) found at http://www.peci.org/library/mcpgs.htm indicate anticipated level of detail for Pre-functional Checklists.

B. Contractor is responsible for filling out Pre-functional Checklists, after completion of installation and before startup; witnessing by the Commissioning Authority is not required unless otherwise specified.
1. Each line item without deficiency is to be witnessed, initialed, and dated by the actual witness; checklists are not complete until all line items are initialed and dated complete without deficiencies.
2. Checklists with incomplete items may be submitted for approval provided the Contractor attests that incomplete items do not preclude the performance of safe and reliable Functional Testing; re-submission of the Checklist is required upon completion of remaining items.
3. Individual Checklists may contain line items that are the responsibility of more than one installer; Contractor shall assign responsibility to appropriate installers or subcontractors, with identification recorded on the form.
4. If any Checklist line item is not relevant, record reasons on the form.
5. Contractor may independently perform startup inspections and/or tests, at his option.
6. Regardless of these reporting requirements, Contractor is responsible for correct startup and operation.
7. Submit completed Checklists to Commissioning Authority within two days of completion.

C. Commissioning Authority is responsible for furnishing the Pre-functional Checklists to Contractor.
1. Initial Drafts: Contractor is responsible for initial draft of Pre-functional Checklist where so indicated in the Contract Documents.
2. Provide all additional information requested by Commissioning Authority to aid in preparation of checklists, such as shop drawing submittals, manufacturers' startup checklists, and O&M data.
3. Commissioning Authority may add any relevant items deemed necessary regardless of whether they are explicitly mentioned in the Contract Documents or not.
4. When asked to review the proposed Checklists, do so in a timely manner.

D. Commissioning Authority Witnessing is Required for:
1. Each piece of primary equipment.
2. A sampling of non-primary equipment, as allowed by the commissioning plan.

E. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.
1. If difficulty in correction would delay progress, report deficiency to the Commissioning Authority immediately.

3.5 FUNCTIONAL TESTS

A. A Functional Test is required for each item of equipment, system, or other assembly specified to be commissioned, unless sampling of multiple identical or near-identical units is allowed by the final test procedures.

B. Contractor is responsible for execution of required Functional Tests, after completion of Pre-functional Checklist and before closeout.

C. Commissioning Authority is responsible for witnessing and reporting results of Functional Tests, including preparation and completion of forms for that purpose.

D. Contractor is responsible for correction of deficiencies and re-testing at no extra cost to Owner; if a deficiency is not corrected and re-tested immediately, the Commissioning Authority will document the deficiency and the Contractor's stated intentions regarding correction.
   1. Deficiencies are any condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents or does not perform properly.
   2. Use the standard form provided with copies submitted to Owner and Contractor.
   3. When the deficiency has been corrected, the Contractor completes the form certifying that the item is ready to be re-tested and returns the form to the Commissioning Authority; the Commissioning Authority will reschedule the test and the Contractor shall re-test.
   4. Identical or Near-Identical Items: If 10 percent, or three, whichever is greater, of identical or near-identical items fail to perform due to material or manufacturing defect, all items will be considered defective; provide a proposal for correction within 2 weeks after notification of defect, including provision for testing sample installations prior to replacement of all items.
   5. Contractor shall bear the cost of Owner and Commissioning Authority personnel time witnessing re-testing.
   6. Contractor shall bear the cost of Owner and Commissioning Authority personnel time witnessing re-testing if the test failed due to failure to execute the relevant Pre-functional Checklist correctly; if the test failed for reasons that would not have been identified in the Pre-functional Checklist process, Contractor shall bear the cost of the second and subsequent re-tests.

E. Functional Test Procedures:
   1. Some test procedures are included in the Contract Documents; where Functional Test procedures are not included in the Contract Documents, test procedures will be determined by the Commissioning Authority with input by and coordination with Contractor.
   2. Examples of Functional Testing:
      a. Test the dynamic function and operation of equipment and systems (rather than just components) using manual (direct observation) or monitoring methods under full operation (e.g., the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint).
      b. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc.
      c. Systems are run through all the HVAC control system’s sequences of operation and components are verified to be responding as the sequence's state.
      d. Traditional air or water test and balancing (TAB) is not Functional Testing; spot checking of TAB by demonstration to the Commissioning Authority is Functional Testing.
   3. Some preliminary Functional Test procedures are included in the contract documents; the Commissioning Authority has the authority to modify these and will furnish final versions as applicable.
   4. PECI (Samples) found at http://www.peci.org/library/mcpgs.htm indicate anticipated level of detail for Functional Tests.

F. Deferred Functional Tests: Some tests may need to be performed later, after substantial completion, due to partial occupancy, seasonal requirements, design, or other conditions. Performance of these tests remains the Contractor's responsibility regardless of timing.

G. Factory Tests: Commissioning Authority and Contractor are responsible for coordinating testing of equipment at the factory by factory personnel, to ensure compliance with commissioning requirements.

H. Field Tests By Others: Where Functional Tests are indicated as to be performed by others not subject to the Contract Documents, those tests are not subject to these commissioning requirements.

3.6 SENSOR AND ACTUATOR CALIBRATION

A. Calibrate all field-installed temperature, relative humidity, carbon monoxide, carbon dioxide, and pressure sensors and gages, and all actuators (dampers and valves) on a given piece of equipment. Sensors installed in the unit at the factory with calibration certification provided need not be field calibrated.

B. Calibrate using the methods described below; alternate methods may be used, if approved by Commissioning Authority and Owner beforehand. See PART 2 for test instrument requirements. Record methods used on the relevant Pre-functional Checklist or other suitable forms, documenting initial, intermediate and final results.

C. All Sensors:
   1. Verify that sensor location is appropriate and away from potential causes of erratic operation.
   2. Verify that sensors with shielded cable are grounded at one end only.
   3. For sensor pairs that are used to determine a temperature or pressure difference: Ensure temperature sensors read within 2°F of each other when sensing identical conditions. For pressure sensors make sure instruments read equally within a tolerance equal to 2% of the reading of the instruments.
   4. Tolerances for critical applications may be tighter.

D. Sensors Without Transmitters - Standard Application:
   1. Make a reading with a calibrated test instrument within 6 inches of the site sensor.
   2. Verify that the sensor reading, via the permanent thermostat, gage or building automation system, is within the tolerances in Part F below of the instrument-measured value.
   3. If not, install offset, calibrate or replace sensor.

E. Sensors With Transmitters - Standard Application.
   1. Disconnect sensor.
   2. Connect a signal generator in place of sensor.
   3. Connect ammeter in series between transmitter and building automation system control panel.
   4. Using manufacturer’s resistance-temperature data, simulate minimum desired temperature.
   5. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter.
   6. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the building automation system.
   7. Record all values and recalibrate controller as necessary to conform with specified control ramps, reset schedules, proportional relationship, reset relationship and P/I reaction.
   8. Reconnect sensor.
   9. Make a reading with a calibrated test instrument within 6 inches of the site sensor.
   10. Verify that the sensor reading, via the permanent thermostat, gage or building automation system, is within the tolerances in Part F below of the instrument-measured value.
   11. If not, replace sensor and repeat.
   12. For pressure sensors, perform a similar process with a suitable signal generator.

F. Sensor Tolerances for Standard Applications: Plus/minus the following maximums:
   1. Watthour, Voltage, Amperage: 1 percent of design.
   2. Pressure, Air, Water, Gas: 3 percent of design.
   3. Air Temperatures (Outside Air, Space Air, Duct Air): 0.4 degrees F.
   4. Relative Humidity: 4 percent of design.
   5. Barometric Pressure: 0.1 inch of Hg.
   6. Flow Rate, Air: 10 percent of design.
   7. Flow Rate, Water: 4 percent of design.
   8. AHU Wet Bulb and Dew Point: 2.0 degrees F.
   9. Hot Water Coil and Boiler Water Temperature: 1.5 degrees F.
   10. Cooling Coil, Chilled and Condenser Water Temperatures: 0.4 degrees F.

11. Combustion Flue Temperature: 5.0 degrees F.
12. Oxygen and CO2 Monitors: 0.1 percentage points.
13. CO Monitor: 0.01 percentage points.
14. Natural Gas and Oil Flow Rate: 1 percent of design.

G. Critical Applications: For some applications more rigorous calibration techniques may be required for selected sensors. Describe any such methods used on an attached sheet.

H. Valve/Damper Stroke Setup and Check:
1. For all valve/damper actuator positions checked, verify the actual position against the control system readout.
2. Set pump/fan to normal operating mode.
3. Command valve/damper closed; visually verify that valve/damper is closed and adjust output zero signal as required.
4. Command valve/damper to open; verify position is full open and adjust output signal as required.
5. Command valve/damper to a few intermediate positions.
6. If actual valve/damper position does not reasonably correspond, replace actuator or add pilot positioner (for pneumatics).

I. Isolation Valve or System Valve Leak Check: For valves not associated with coils.
1. With full pressure in the system, command valve closed.
2. Use an ultra-sonic flow meter to detect flow or leakage.

3.7 TEST PROCEDURES - GENERAL

A. Provide skilled technicians to execute starting of equipment and to execute the Functional Tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

B. Provide all necessary materials and system modifications required to produce the flows, pressures, temperatures, and conditions necessary to execute the test according to the specified conditions. At completion of the test, return all affected equipment and systems to their pre-test condition.

C. Sampling: Functional Testing of fewer than the total number of multiple identical or near-identical items may be permitted by the Commissioning Authority.
1. Identical Units: Defined as units with same application and sequence of operation; only minor size or capacity difference.
2. Sampling is not allowed for:
   a. Major equipment.
   b. Life-safety-critical equipment.
   c. Pre-functional Checklist execution.

D. Manual Testing: Use hand-held instruments, immediate control system readouts, or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the “observation”).

E. Simulating Conditions: Artificially create the necessary condition for the purpose of testing the response of a system; for example apply hot air to a space sensor using a hair dryer to see the response in a VAV box.

F. Simulating Signals: Disconnect the sensor and use a signal generator to send an amperage, resistance or pressure to the transducer and control system to simulate the sensor value.

G. Over-Writing Values: Change the sensor value known to the control system in the control system to see the response of the system; for example, change the outside air temperature value from 50 degrees F to 75 degrees F to verify economizer operation.

H. Indirect Indicators: Remote indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100 percent closed, are considered indirect indicators.

I. Monitoring: Record parameters (flow, current, status, pressure, etc.) of equipment operation using data-loggers or the trending capabilities of the relevant control systems; where monitoring of specific points is called for in Functional Test Procedures:
   1. All points that are monitored by the relevant control system shall be trended by Contractor; at the Commissioning Authority's request, Contractor shall trend up to 20 percent more points than specified at no extra charge.
   2. Other points will be monitored by the Commissioning Authority using data-loggers.
   3. At the option of the Commissioning Authority, some control system monitoring may be replaced with data-logger monitoring.
   4. Provide hard copies of monitored data in columnar format with time down left column and at least 5 columns of point values on same page.
   5. Graphical output is desirable and is required for all output if the system can produce it.
   6. Monitoring may be used to augment manual testing.

3.8 OPERATION AND MAINTENANCE MANUALS

A. See Section 01 78 00 - Closeout Submittals for additional requirements.

B. Add design intent documentation furnished by Architect to manuals prior to submission to Owner.

C. Submit manuals related to items that were commissioned to Commissioning Authority for review; make changes recommended by Commissioning Authority.

D. Commissioning Authority will add commissioning records to manuals after submission to Owner.

END OF SECTION