**PART 1 – GENERAL**

**1.01 SECTION INCLUDES**

1. This Section defines the Contractor's responsibilities with respect to Commissioning. The Contractor shall include this scope in the bid. This includes administrative and procedural requirements as well as a detailed execution of Commissioning. This Section supplements Section 01420 – Testing and Inspection, Section 01450 – Test and Balance, as well as the Division 15 – Mechanical, and Division 16 – Electrical sections which specify testing procedures. This Section also defines the systems and equipment to be commissioned. For projects that have Specification Section 01400 – 01405, Contractor Construction Quality Control, the Commissioning schedule and activities as defined in the approved Commissioning Plan shall be incorporated by Contractor into the Construction Quality Control (CQC) plan. The Commissioning Agent (CxA) will be part of the Owner’s Quality Assurance (QA) Team and participate in the review and execution of the Project Construction Quality Control (CQC) plan, along with the Contractor, Owner’s Authorized Representative (OAR), Project Inspector (PI), and Architect of Record (AOR).

**1.02 DEFINITIONS**

A. Commissioning (Cx): A systematic process which verifies that the building systems perform according to the Owner’s Design Intent/Basis of Design (ODI/BOD). Commissioning includes system documentation, equipment startup, control system calibration, Testing, Adjusting and Balancing (TAB) verification, performance testing, and training.

B. Commissioning Agent (CxA): A District appointed entity that plans and coordinates all activities which implement Commissioning as outlined by the Owner’s Design Intent/Basis of Design (ODI/BOD). The CxA has overall responsibility for planning and coordinating Commissioning. Commissioning activities that take place during construction shall be based on the Contractor’s construction schedule.

C. Commissioning Plan (CxP): A contract document that identifies the project Commissioning goals, Owner’s Design Intent/Basis of Design, commissioning milestones, coordination requirements, and project specific Prefunctional Equipment Checklists and Functional Performance Test Checklists. The CxP shall be incorporated by Contractor into the Construction Quality Control Plan.

D. Prefunctional Equipment Checklist (PEC): A form for each piece of equipment referenced in ‘1.08 SYSTEMS TO BE COMMISSIONED’ that must be completed by the Contractor as a prerequisite to the equipment’s Functional Performance Test (FPT). Sample checklists and PEC forms are included in the CxP. The checklists and forms are completed by the Contractor and verified by the CxA.

E. Functional Performance Test (FPT): A documented test designed by the Commissioning Agent (CxA) that verifies the dynamic functioning and operation of equipment and systems with the goal of verifying that the Owners’ Design Intent/Basis of Design (ODI/BOD) is met. Sample testing requirements and forms are included in the CxP. Test procedures are performed by the Contractor and witnessed by the PI and CxA.

F. Acceptance - A formal action, taken by a person with appropriate authorization, to declare that some aspect of the project meets defined requirements – thereby permitting subsequent activities to proceed.

G. Checklists- Documents that are developed and used during all phases of commissioning to verify that the ODI/BOD is being achieved. This includes checklists for general verification, testing, training, and other specific requirements. Various checklists are prepared by the CxA and the contractor to document completion of testing and/or commissioning of equipment and systems.

I. Coordination Drawings - Drawings showing the work of all trades to illustrate that equipment can be installed in the space allocated without compromising equipment function or access for maintenance and replacement. These drawings graphically illustrate and dimension manufacturers’ recommended maintenance clearances.

K. Control system – A component of an environmental, HVAC, electrical, lighting, or energy management system for the reporting, monitoring and/or issuing of commands to and/or from field devices.

L. Data logging -The monitoring and recording of flows, currents, status, pressures, etc., of equipment using stand-alone data recorders separate from the installed control system or the trending capabilities of those control systems.

M. Deficiency - A condition that is not in compliance with the contract documents relative to the installation or function of a component, piece of equipment, or system.

N. Factory Testing - Testing of equipment at the factory or on-site by factory personnel with, or without, an owner’s representative present.

O. Issues Log- A formal and ongoing record of problems or concerns – and their resolution – that have been raised by members of the commissioning team during the course of commissioning.

P. Seasonal Performance Tests - Tests that are performed when weather conditions are comparable to the design conditions based or the design conditions can be simulated.

R. Simulated Condition - Condition that is created for the purpose of testing the response of a system (e.g., raising/lowering the set point of a thermostat to see the response in a VAV box).

S. Startup - The initial starting or activating of dynamic equipment.

T. Systems Manual - A system-focused composite document that includes the operation manual, maintenance manual, manufacturer’s technical diagrams and additional information of use to the owner during facility occupancy and operation.

U. Test Procedure- A written protocol that defines methods, procedures, personnel, and expected outcomes for tests conducted on components, equipment, assemblies, systems, and interfaces among systems. The test procedures are specified in the Commissioning Plan and Technical Specifications sections of the contract documents and the CxP.

V. Training Plan -A written document that details the expectations, schedule, budget, and deliverables of commissioning activities related to the training of facility operating and maintenance personnel, users, and occupants.

X. Verification - The process by which specific documents, components, equipment, assemblies, systems, and interfaces among systems are confirmed to comply with the criteria described in the Owner’s Design Intent/Basis of Design. Verification testing is performed per the prescribed test procedure(s) by the contractor and witnessed by the IOR and CxA.

Y, Trending – The analysis of system performance gathered over a period of time by a building management system or other electronic data gathering equipment.

**1.03 RELATED WORK**

1. Division 01 – Supplemental Conditions
2. Section 01 11 23 – Phasing of the Work
3. Section 01 25 00 - Allowances
4. Section 01 31 13 – Project Coordination
5. Section 01 33 00 - Submittals
6. Section 01 32 130 – Construction Project Schedule
7. Section 01 45 23 - Testing and Inspection
8. Section 01 50 00 – Construction Facilities and Temporary Controls
9. Section 01 25 13 – Substitutions and Product Options
10. Section 01 77 00 – Contract Close-Out
11. Section 01 78 36 – Warranties and Bonds
12. Section 01 77 50 – Maintenance & Operation Staff Demonstration and Training
13. Section 23 08 00 – HVAC Systems Commissioning
14. Section 23 09 23 – Environmental Controls and Energy Management Systems Commissioning
15. Section 26 08 00 – Electrical Systems Commissioning

**1.04 REFERENCES**

1. ASHRAE Guideline 1-1996 HVAC&R Commissioning Process
2. Associated Air Balance Council Commissioning Guidelines
3. CHPS Best Practices Manual, Volume V: Commissioning

**1.05 COORDINATION**

Items listed below require coordination between the Contractor, OAR, PI, and CxA.

1. Cx Schedule and Meeting Venue.
2. Commissioning Meeting Attendance
3. Completion of Prefunctional Equipment Checklists (PEC)
4. Functional Performance Testing (FPT)
5. Operations & Maintenance Manual Submittal and Training
6. Documentation of Prefunctional Equipment Checklists (PEC) & Functional Performance Testing (FPT)Inspections

**1.06 SUBMITTALS**

1. Submittal documentation required for the commissioning work will be identified by the CxA and integrated into the normal submittal process and protocol of the construction team. At minimum, the CxA’s documentation request will identify the manufacturer and model number, the manufacturer’s printed installation and detailed startup procedures, full sequences of operation, O&M data, performance data, any performance test procedures, control drawings and details of owner contracted tests. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted. All such documentation will be included by subcontractors in their O&M manual submittals.
2. The CxA will review and recommend acceptance or any required revision to the OAR for all submittals related to the commissioned equipment for conformance with the contract documents as they relate to commissioning, performance of the equipment, and their adequacy of test procedures. This review is intended primarily to aid in the development of performance procedures and only secondarily to verify compliance with equipment specifications. The CxA will notify the OAR and FUSD of items missing or areas that are not in conformance with contract documents and which require resubmission.
3. Submittal of O&M manual documentation does not constitute compliance. The CxA will review all such document submittals and recommend to OAR and FUSD their acceptance or any required revisions.
4. Submittal documentation specified in Specifications 23 90 00, 23 08 00 and 26 08 00.

**1.07 CONTRACTOR RESPONSIBILITIES**

1. The general responsibilities of Contractor and Subcontractors in commissioning are defined in this section. The specific responsibilities are in the Division 23 and Division 26 Technical Specifications. All parties shall:

1. Follow the Commissioning Plan.

2. Attend commissioning meetings.

1. Contractor, its design team, sub-contractors and vendors shall assign representatives with expertise and authority to act on their behalf and schedule them to participate in and perform required commissioning activities including, but not limited to, providing all tools, or the use of tools, to start, check-out and test equipment and systems, except for specified testing with portable data recorders which shall be supplied and installed by the CxA.

Contractor and subcontractors shall:

* 1. Facilitate coordination of Commissioning.
  2. Incorporate Commissioning activities (the CxP) into the Project Schedule.
  3. Coordinate and direct Commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules and technical expertise.
  4. Participate in up to three (3) meetings specifically for Commissioning-related items as scheduled by the OAR.
  5. Review and accept construction checklists developed by the CxA.
  6. Provide information required to perform commissioning tasks, including O&M materials, contractor startup and checkout lists.
  7. No later than 60 days prior to startup of the first piece of major equipment, meet with the CxA and OAR to finalize the detailed commissioning procedures and schedule.
  8. Before startup, provide detailed startup procedures including current control sequences and interlocks to comply with the detailed functional test plans.
  9. Provide one (1) additional copy of all submittals required in Section 01 33 00 for all systems being commissioned for review of compliance with commissioning needs by the CxA.
  10. Develop and coordinate a startup and initial systems checkout plan with subcontractors and ensure that all subcontractors and vendors execute their commissioning responsibilities according to the contract documents.
  11. Review TAB execution plan.
  12. Oversee sufficient testing of the control system before TAB is executed.
  13. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
  14. Coordinate retesting as necessary until satisfactory performance is achieved
  15. Complete checklists as work is completed and provide to OAR on a weekly basis.
  16. Review equipment warranties to ensure that the owner’s responsibilities to keep warranties in force are clearly defined.
  17. Oversee and coordinate the training of the owner’s personnel.
  18. Review and approve the preparation of the O&M manuals including clarifying and updating of original sequences of operation to as-built/as-tested conditions.
  19. Coordinate development of a systems manual.

**1.08 SYSTEMS TO BE COMMISSIONED**

Systems to be commissioned for this project include, but are not limited to, those for which Specifications are included in Contract Documents and as listed in:

* Specification 23 90 00, Paragraph 1.07 - Equipment And Systems To Be Commissioned
* Specification 20 80 00
* Specification 26 08 00, Paragraph 3.01.B

**PART 2 – PRODUCTS**

**2.01 TEST EQUIPMENT**

A. All standard testing equipment required to perform startup and initial checkout and required performance testing shall be provided by the contractor for the equipment being tested. This includes, but is not limited to, two-way radios and meters, etc. Testing specified as requiring portable data recorders will be performed with data recorders supplied and installed by the CxA.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance within the tolerances specified in the specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a current certified calibration to an accuracy of 0.5 degree F and a resolution of + or - 0.1 degree F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer’s recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

**PART 3 – EXECUTION**

* 1. **MEETINGS**

1. Commissioning Kick-off Meeting: Within 15 days following issuance of Notice-to-Proceed 1 (NTP 1), the OAR will schedule a Construction Quality Control kick-off meeting. The PI, Cx team and Contractor Quality Control representative will be in attendance. CxA shall prepare and distribute a list of commissioning topics to be placed on the meeting agenda. Attendance at this meeting and participation in the Commissioning topics is mandatory for the following Contractor personnel:
2. Contractor’s Quality Control Engineer and Commissioning Representative
3. Contractor’s Project Scheduling personnel
4. Mechanical Subcontractors
5. Electrical Subcontractors
6. TAB Subcontractor
7. Controls Subcontractors
8. Other Commissioning Meetings. Other Cx meetings will routinely be scheduled and generally be conducted in conjunction with regularly scheduled site meetings as the Construction progresses. The Commissioning portion of meetings will cover upcoming implementation and coordination of the CxP, deficiency resolution, and planning issues with particular subcontractors.

**3.02 GENERAL REQUIREMENTS FOR TESTING**

Complete the following at least two weeks prior to Functional Performance Testing:

A. Arrange for Commissioning observations to be performed by the CxA.

B. Completion and acceptance of the Start-up Plan by the CxA.

C. Correction of deficiencies identified during start-up.

D. Recording of pretest set points.

**3.03 FUNCTIONAL PERFORMANCE TESTING (FTP)**

A. Undertake functional testing after the testing requirements listed in Paragraph 3.02 are completed.

B. Equipment: Refer to Part 2 of this Section for test equipment requirements.

C. Perform FPT under the observation of the CxA who will verify the results of the functional test procedures documented by Contractor.

D. Perform all specified tests according to approved testing procedures / plan.

1. Verify and test performance using actual conditions whenever possible.

2. Simulate conditions when it is not practical to test under actual conditions or when required seasonal testing conditions are not present. The procedure to be used shall be submitted to the OAR for PI and CxA review and acceptance at least one week before simulated testing is to occur. After test, return settings to normal operating conditions.

3. Alter set points when simulating conditions is not practical and when written approval to do so is received from OAR.

4. Override sensor values with a signal generator when actual or simulated conditions and altering set points are not practical. Do not use the sensor to act as the signal generator to simulate conditions or override values.

E. Functional Performance Testing (FPT) Documentation: This Section specifies the general description of the minimum Division 23 and Division 26 Functional Performance Testing documentation requirements that the Contractor shall provide. The CxA will develop testing procedures in accordance to the requirements of this Section and incorporate into the Cx Plan that Contractor must follow and document. The testing documentation must include the following information:

1. Test number.
2. Date and time of the test.
3. Indication of whether the record is for a first test or retest following correction of a problem or issue.
4. Identification of the system, subsystem, assembly, or equipment.
5. Conditions under which the test was conducted, including (as applicable) ambient conditions, set points, override conditions, and status and operating conditions that impact the results of the test.
6. Expected performance of the systems and assemblies at each step of the test.
7. Narrative description of observed performance of the system, equipment, or assembly.
8. Notation to indicate whether the observed performance at each step meets the expected results.
9. Issue number, if any, generated as the result of the test.
10. Dated signatures of the person performing the test and a witness.

F. The CxA and PI will review and OAR, if applicable, accept functional testing results. Deficiencies found during testing shall be submitted to the OAR and, if required, based on the recommendation of PI, by the OAR, corrected by the Contractor and retested. Where there is a dispute over a deficiency, OAR, based on the recommendation of AOR and PI, shall be the final authority.

G. Problem Solving: The burden of responsibility to solve, correct and retest problems is with the Contractor and the design team with OAR, based on the recommendations of the AOR, CxA and PI, having final responsibility for acceptance of the Work.

H. Substantial Completion: All testing, retesting, and acceptance of Functional Performance Testing shall be completed prior to issuing the Certificate of Substantial Completion. FPT may be conducted following building occupancy; however, all associated and reasonable additional costs incurred by the CxA shall be assessed against Contractor Retention or Withhold funds.

I. Definiencies in the Cx Plan Functional Performance Test Checklist: If there is any Functional Performance Test Checklist missing for any particular piece of equipment, the Contractor shall inform the CxA and ask for an updated Functional Performance Test Checklist.

**3.04 RETESTING**Re-testing shall be required when a specific Prefunctional Checklist or Start-up test item, reported to have been successfully completed by Contractor or determined during functional testing to be faulty or incomplete, is identified.

1. Contractor shall be provided one retest opportunity at no additional cost when Contractor can affect corrections within two (2) hours of identification of the need to retest. Costs for retesting beyond one retest, or when Contractor cannot affect corrections within two (2) hours of identification of the need to retest, will be assessed against Contractor funds if OAR determines, based upon the recommendation of the PI and CxA, that the Contractor is responsible for the deficiency. These costs shall include all reasonable expenses incurred by the CxA.
2. For a deficiency identified during functional testing, but not included in the approved Start-up Plan, OAR will direct retesting of the equipment with no costs assessed against Contractor for this initial retesting. Costs for retesting, when Contractor cannot affect corrections within two (2) hours of identification of the need to retest, will be assessed against Contractor funds if OAR determines, based upon the recommendation of the PI and CxA, that the Contractor is responsible for the deficiency. These costs shall include all reasonable expenses incurred by the CxA.
3. Retesting shall not be considered a reason for a claim of delay or for a time extension by the Contractor.
   1. **STARTUP, CONSTRUCTION CHECKLISTS, AND INITIAL CHECKOUT**
4. The following procedures apply to all equipment/systems to be commissioned:
   1. General. Contractor shall use PECs to verify that the equipment and systems are fully connected and operational. PECs for a given system must be successfully completed and accepted prior to startup and formal performance testing of equipment or subsystems of the given system.
   2. Startup and Checkout Plan. The CxA will assist the project commissioning team members responsible for startup of any equipment. The primary role of the CxA in this process is to ensure that there is written documentation and that each of the manufacturer-recommended procedures has been completed. The CxA shall provide all the required pre-functional checklists and forms to be completed by Contractor in the CxP. The CxA will ensure that the PI and/or District Special Inspectors are informed as to the planned and scheduled startup and checkout procedures.
5. Sample Pre-Functional checklists are provided as an attachment to the CxP. These checklists indicate required procedures to be executed prior to equipment startup.
6. Contractor shall determine which trade is responsible for executing and documenting each of the line item tasks and transmit the checklists to the responsible subcontractors. Each form may have more than one trade responsible for its execution.
7. The contractor/subcontractor responsible for the purchase and/or installation of the equipment shall develop a comprehensive startup plan (with assistance from the CxA) by combining the manufacturer’s detailed startup and checkout procedures and the pre-functional checklists.
8. The contractor/subcontractor shall submit the full startup plan to the CxA for review and approval.
9. PI will review and accept, based on CxA recommendation, the procedures and the documentation format for reporting. The CxA will return the procedures and the documentation format to Contractor through the OAR.
10. Contractor shall transmit the full startup plan to the subcontractors for their review and use.
11. Sensor and Actuator Calibration. All field-installed temperature, relative humidity, CO, CO2, refrigerant, O2, and/or pressure sensors and gages, and all actuators (dampers and valves) on all equipment shall be calibrated. Verify that all locations are appropriate and away from causes of erratic operation. Submit to the CxA through the OAR the calibration methods and results. All test instruments shall have had a current certified calibration record. Sensors installed in the unit at the factory with calibration certification provided need not be field calibrated. Contractor to field verify all installed sensors.

Sensor Calibration Methods

All Sensors-- Verify that all sensor locations are appropriate and away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading of each other for pressure.

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

Sensors With Transmitters -- Standard Application. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, install offset in BAS and calibrate or replace sensor.

Tolerances, Standard Applications

|  |  |
| --- | --- |
| Sensor | Required Tolerance (+/-) |
| Cooling coil, chilled and condenser water temps | 0.4F |
| AHU wet bulb or dew point | 2.0F |
| Hot water coil and boiler water temp | 1.5F |
| Outside air, space air, duct air temps | 0.4F |
| Watthour, voltage & amperage | 1% of design |
| Pressures, air, water and gas | 3% of design |
| Flow rates, air, water | 10% of design |
| Flow rates, water Relative humidity | 4% of design |
| Combustion flue temps | 5.0F |
| Oxygen or CO2 monitor | 0.1 % pts |
| CO monitor | 0.01 % pts |
| Natural gas and oil flow rate | 1% of design |
| Barometric pressure | 0.1 in. of Hg |

Valve and Damper Stroke Setup and Check EMS Readout-- For all valve and damper actuator positions checked, verify the actual position against the BAS readout. Set pumps or fans to normal operating mode. With the command calve and damper closed, visually verify that the command valve or damper is closed and adjust output zero signal as required. With the command valve or damper open, visually verify that the position is full open and adjust output signal as required. Set command valve or damper to a few intermediate positions. If actual valve or damper position doesn’t reasonably correspond, repair or replace actuator.

Closure for heating coil valves (NO) -- Set heating setpoint 20°F above room temperature. Visually observe valve open. Set heating setpoint to 20°F below room temperature. Visually observe the valve close. Restore to normal.

Closure for cooling coil valves (NC) -- Set cooling setpoint 20°F above room temperature. Visually observe the valve close. Set cooling setpoint to 20°F below room temperature. Visually observe valve open. Restore to normal.

1. Execution of Construction Checklists and Startup.

1. Four weeks prior to the scheduled startup, Contractor shall coordinate startup and checkout with the PI and CxA. The execution and approval of the PECs, startup, and checkout shall be directed and performed by Contractor, subcontractor or vendor. Signatures are required of the applicable subcontractors for verification of completion of their work.

2. The PI shall observe, as a minimum, the procedures performed for each piece of primary equipment, unless there are multiple units; in which case a sampling strategy may be used. The CxA shall observe all testing.

3. For lower-level components of equipment, (e.g., sensors, controllers), the CxA shall observe a sampling of the startup procedures.

4. Pre-functional checklist documentation, identified in the CxP, is to be used by the sub-contractor to document that equipment is ready for startup.

5. The subcontractors and vendors shall execute startup and provide the CxA, through the OAR, with a signed and dated copy of the completed startup and construction checklists.

6. Only individuals of the contractor or sub-contractor (technicians, engineers, manufacturer’s representatives/vendors, supervisors, etc.) who have direct knowledge and have witnessed that a line item task on the construction checklist was actually performed shall check off that item.

1. Deficiencies, Non-Conformance, and Approval in Checklists and Startup (Issues Log).

1. The contractor shall ensure that the subcontractors clearly list any outstanding items of the initial startup and construction checklist procedures that were not completed successfully, on an attached sheet. The form and any outstanding deficiencies shall be provided, through the PI, to the CxA within two days of test completion.

2. The CxA will review the report and issue either a non-compliance report or acceptance form, through the PI, to Contractor. The installing subcontractors or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, shall notify the PI as soon as outstanding items have been corrected, and resubmit an updated startup report with a Statement of Correction on the original non-compliance report. When satisfactorily completed, the CxA will recommend approval of the execution of the checklists and startup of each system.

Items left incomplete, which later cause deficiencies or delays during performance testing, may result in assessments to Contractor. Refer to Paragraph 3.05, herein, for details.

* 1. **DEFERRED TESTING**

A. Unforeseen Deferred Tests: Checks or tests not completed due to the incomplete Work, required occupancy conditions, or other conditions may be delayed upon approval of the OAR based upon the recommendation of the PI and CxA. These tests may be conducted in the same manner as the seasonal tests.

B. Seasonal Testing: Complete seasonal testing, when weather or other testing conditions do not emulate the system’s design conditions, employing simulated conditions acceptable to OAR and FUSD based upon the recommendation of the PI and CxA. The OAR will coordinate with Contractor, and CxA validate, this activity. Tests shall be executed, documented and deficiencies corrected by the Contractor, with the PI and the CxA witnessing. The Contractor shall make adjustments to the Operations and Maintenance Data, as necessary.

* 1. **DOCUMENT REVIEW**

1. General: See Paragraph 1.06 for submittal requirements.
2. Operations & Maintenance Manuals: Refer to 01 77 50 for specific requirements.
   1. **OPERATOR TRAINING**

A. The CxA, under the direction of the OAR, coordinates and verifies training completion as shown in Section 01 77 50. Forms and procedures are also described in the CxP.

**END OF SECTION**