

SECTION 01 91 15
TOTAL BUILDING COMMISSIONING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. General requirements for coordinating and scheduling commissioning.
2. Commissioning meetings.
3. Commissioning reports.
4. Use of test equipment, instrumentation, and tools for commissioning.
5. Construction checklists, including, but not limited to, installation checks, startup, and performance tests.
6. Commissioning tests.
7. Adjusting, verifying, and documenting identified systems and assemblies.

B. Work included under this section includes a complete and thorough investigation of equipment and systems indicated in Part 3 of section. In order to ensure proper installation and operation of components and systems. Contractor shall perform commissioning as described herein to accomplish the tasks, and goals of commissioning. Systems to be evaluated include but are not limited to:

1. HVAC (Heating, Ventilation, and Air Conditioning) components and equipment.
2. HVAC system: Interaction of cooling, heating, and comfort delivery systems.
3. Lighting Control System and interface with daylighting.
4. Building Envelope (walls, roof, windows, infiltration, etc.).
5. Life Safety Systems (Fire Alarm and Suppression).
6. Electrical and Alternative Energy Systems (propane generator, photovoltaic panels, etc.).
7. Access Control/ Security Systems.
8. Lightning Protection.
9. Plumbing lift station.

C. Building commissioning activities and documentation are described in the following reference material: United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED™) rating program, American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Guideline 0-2005, The Commissioning Process, and National Institute of Building Sciences (NIBS) Guidelines.

D. Work under this section does not include wastewater treatment process equipment or unit processes. See Section 01 91 14, Equipment Testing and Facility Startup, for testing and certification requirements related to the wastewater treatment process.

- E. National Park Service (NPS) personnel, Green Consultant, and Architect/Engineer, are not responsible for construction means, methods, job safety, or management function related to commissioning on Job Site.
- F. Related Sections:
 - 1. Section 01 31 00, Project Management and Coordination.
 - 2. Section 01 33 23, Submittal Procedures.
 - 3. Section 01 40 00, Quality Requirements.
 - 4. Section 01 57 19.11, Indoor Air Quality Management.
 - 5. Section 01 57 19.12, Noise and Acoustics Management.
 - 6. Section 01 77 00, Closeout Procedures.
 - 7. Section 01 78 23, Operation and Maintenance Data.
 - 8. Section 01 79 00, Demonstration and Training.
 - 9. Section 01 81 13, Sustainable Design Requirements for Non-LEED™ Projects.

1.2 DEFINITIONS

- A. Acceptance Criteria: Threshold of acceptable work quality or performance specified for a commissioning activity.
- B. Construction Checklist: Form used by Contractor to verify appropriate components are onsite, ready for installation, correctly installed and functional.
- C. Contractor's Commissioning Representative: (CCxR) Contractor's designated individual to coordinate, manage, and execute commissioning processes of the contracting organizations.
- D. Commissioning Plan (CCxP): Plan that provides structure, schedule and coordination planning for commissioning process proposed specifically for this Project. CCxP includes Personnel, activities, and a description of Infrastructure, and list of instruments and logging devices that will be used during Commissioning.
- E. Deficiency: Condition in the installation or function of a component, piece of equipment or system not in compliance with Contract Documents, does not perform properly or is not complying with Basis of Design.
- F. Functional Performance Test (FPT): Test of dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Functional testing is the dynamic testing of systems (rather than just components) 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). 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. The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. Traditional air or water test and balancing (TAB) is not

functional performance testing, in the commissioning sense of the word. TAB's primary work is setting up the system flows and pressures as specified, while functional testing is verifying that which has already been set up. The CCxR develops the sequentially written functional test procedure forms, and oversees and documents the actual testing, which is performed by the installing contractor or vendor. The CCxR creates worksheets from these forms which include procedures required to accommodate actual equipment, means and methods used in the Project. Functional Performance Tests are performed after pre-functional checklists and startup is complete.

- G. Manual Test: Using hand-held instruments, control system readouts or direct observation to verify performance (contrasted to analyzing electronically monitored data taken over time to make the "observation").
- H. Monitoring: Recording of parameters (flow, current, status, pressure, etc.) of equipment operation using data loggers or the trending capabilities of control systems.
- I. Government's Project Requirements: Document originated by Designer that details functional requirements of Project and expectations of use and operation, including Project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information. Document is updated, with input from Contracting Officer (CO) as required as Project is finished.
- J. Pre-functional Checklist: List of items to inspect and elementary component tests to conduct to verify proper installation of equipment. Pre-functional checklists are primarily static inspections and procedures to prepare equipment or system for initial operation (e.g., belt tension, oil levels ok, labels affixed, gages in place, sensors calibrated, etc.). However, some pre-functional checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring voltage imbalance on a three-phase pump motor of a chiller system). Pre-functional" refers to "before" functional testing. Pre-functional checklists augment and are combined with the equipment manufacturer's start-up checklist.
- K. Seasonal Performance Tests: Functional Performance Tests deferred until system(s) will experience seasonal conditions closer to their design conditions.
- L. Systems Manual: System focused composite document that includes operational manual, maintenance manual, and additional information of use to Government during Occupancy and Operation Phase.
- M. Total Building Commissioning (TBC): Quality-focused process for verifying and documenting that facility, systems and assemblies are planned, designed, installed, and tested to comply with Government's Project Requirements. Requirements specified here are limited to construction phase commissioning activities.

1.3 COMMISSIONING TEAM

- A. Members Appointed by Contractor(s): Individuals, each having authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action.

1. CCxR (Contractor's Commissioning Representative):

- a. CCxR shall be approved by Contracting Officer and satisfy as many of the following requirements as possible:

- 1) Certified in Commissioning by nationally accredited organization (i.e., Associated Air Balance Council (AABC), Association of Energy Engineers (AEE), Building Commissioning Association (BCA), and National Environmental Balancing Bureau (NEBB))
- 2) Acted as principal Commissioning Authority where total building commissioning approach (including building envelope) was used for at least three projects of comparable size, type, and scope.
- 3) Technical training in Mechanical, Electrical, and/or fire protection engineering.
- 4) Past commissioning experience.
- 5) Knowledge of national codes.
- 6) Experience in energy-efficient design and control strategy optimization.
- 7) Specific experience with specialty systems relative to particular facility type (i.e., Federal blast and progressive collapse requirements, security systems, etc.).

2. Contractor Quality Control (CQC) Supervisor.

3. Other Representatives may include Project superintendents, installers, suppliers, and specialists.

B. Members Appointed by Contracting Officer:

1. Representatives of facility user and operation and maintenance personnel.
2. Architect and engineering design professionals.

1.4 CONTRACTOR'S RESPONSIBILITIES

- A. Contractor shall assign representatives with expertise and authority to act on its behalf to participate in and perform commissioning process activities including:

1. Perform commissioning tests, as required by technical specifications. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
2. Record and resolve commissioning issues.

3. Attend commissioning team meetings held on variable basis.
4. Integrate and coordinate commissioning process activities with overall Project schedule.
5. Review Construction Checklist attached at end of specification section.
6. Complete construction checklists as Contract Work is completed and provide to Contracting Officer on a basis as determined by the Contracting Officer.
7. Complete commissioning process test procedures.
8. Provide maintenance orientation and inspection for systems, assemblies, equipment, and components based on contract requirements.
9. Provide Commissioning Plan and documentation for final commissioning documentation.
10. Provide measuring instruments and logging devices to record test data and provide data acquisition equipment to record data for complete range of testing for required test period.

1.5 COMMISSIONING DOCUMENTATION

A. Provide the following information:

1. Review of systems manual, submittals, documents, and other commissioning reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Commissioning Plan including Process activities and schedule for completing construction checklists and manufacturer's pre-start and startup checklists for systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of readiness certifying systems, subsystems, equipment, and associated controls are ready for testing.
5. Test and inspection reports and certificates.
6. Corrective action documents.
7. Testing, adjusting, and balancing reports.

1.6 SUBMITTALS

- A. Two-week Look-ahead Schedules: Schedule showing the next two weeks of commissioning related construction activity to include completion dates for each element of commissioning documentation for each major system or subsystem as identified in Paragraph 1.1.B.
- B. Certificates of readiness.
- C. Contractor's Commissioning Representative Qualifications.
- D. Commissioning Plan: Submit within 30 calendar days of authorization to proceed.
 1. Update as necessary during the work to reflect progress on components and systems.

- E. Pre functional checklists.
- F. Contracting Officer's project requirements.
- G. Functional Performance Test Forms: Submit minimum 30 calendar days prior to testing
- H. List of test instrumentation, equipment, and monitoring devices. Include:
 - 1. Make, model, serial number, and application for each instrument, equipment, and monitoring device.
 - 2. Brief description of intended use.
 - 3. Calibration Record Showing:
 - a. Calibration agency, including name and contact information.
 - b. Last date of calibration.
 - c. Range of values for which calibration is valid.
 - d. Certification of accuracy.
 - e. National Institute of Standards and Technology (NIST) traceability certification for calibration equipment.
 - f. Due date of the next calibration.
- I. Deficiency Report and Resolution Record: Document items of non-compliance in materials, installation or operation. Document results from start-up/pre-functional checklists, functional performance testing, and short-term diagnostic monitoring. Include details of components or systems found to be non-compliant with The Drawings and Specifications. Identify adjustments and alterations required to correct system operation and identify who is responsible for making corrective changes.
 - 1. Update as necessary during work to reflect progress on components and systems. Submit updated versions monthly.
- J. Closeout Documentation:
 - 1. Closeout documents for commissioned equipment and systems shall be submitted prior to functional performance testing. These include:
 - a. Record Documents and the Drawings.
 - b. Start-up certificates for commissioned equipment with start-up requirements.
 - c. Systems Manual.
 - d. Include TAB, startup, and Control System check-out reports.

2. Operation and Maintenance (O&M) Submittals (refer to requirements of technical specifications):
 - a. Training Plan:
 - 1) Include for each training session:
 - a) Dates, start and finish times, and locations.
 - b) Outline of the information to be presented.
 - c) Names and qualifications of presenters.
 - d) List of texts and materials required to support training.

PART 2 PRODUCTS

2.1 TEST EQUIPMENT

A. Instrumentation shall:

1. Be of sufficient quality and accuracy to test and measure system performance within tolerances required to determine adequate performance.
 2. Be calibrated on manufacturer's recommended intervals calibration tags permanently affixed to instrument being used.
 3. Be maintained in good repair and operation condition throughout duration of use on this Project.
- B. Standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by Contractor for equipment being tested.
- C. Required commissioning equipment (sensors, transducers, data loggers, etc.) not integral to the systems or equipment installed shall be provided by Contractors Commissioning Representative and shall not become property of the Government.

2.2 PRE-FUNCTIONAL CHECKLIST

- A. Prepare pre functional checklists for equipment and systems to be commissioned.
- B. Pre-functional checklists shall be complementary to Commissioning Plan and Commissioning Schedule.

2.3 FUNCTIONAL TEST PROCEDURE FORMS

- A. Prepare functional test procedure forms for each piece of equipment and each system to be commissioned.

2.4 FUNCTIONAL PERFORMANCE WORKSHEETS

- A. Prepare Functional Performance worksheets, consisting of test procedures and expected results of testing.

2.5 REPORT FORMAT AND ORGANIZATION

A. General Format and Organization:

1. Bind report in three-ring binders.
2. Label front cover and spine of each binder with report title, volume number, project name, Contractor's name, and date of report.
3. Record report on compact disk.
4. Electronic Data: Portable document format (PDF); a single file with outline-organized bookmarks for major and minor tabs and tab contents itemized for specific reports.

B. Commissioning Report:

1. Include table of contents and an index to each test.
2. Include major tabs for each specification section.
3. Include minor tabs for each test.
4. Within each minor tab, include:
 - a. Test specification.
 - b. Pre-startup reports.
 - c. Approved test procedures.
 - d. Test data forms, completed and signed.
 - e. Commissioning issue reports, showing resolution of issues, and documentation related to resolution of issues pertaining to a single test. Group data forms, commissioning issue reports showing resolution of issues, and documentation related to resolution of issues for each test repetition together within minor tab, in reverse chronological order (most recent on top).

PART 3 EXECUTION

3.1 COMMISSIONING PROCESS

- A. Following activities outline general commissioning tasks (requiring development, execution, etc.) and order in which they occur. Specific Commissioning requirements are found in technical specification sections.
 1. Commissioning Scoping Meeting.
 2. Finalize Government's Project Requirements.

3. Commissioning Plan.
4. Prepare pre-functional checklists.
5. Prepare functional performance worksheets.
6. Perform Start-Up/Pre-Functional Checks in accordance with manufacturer's recommendations and pre-functional checklists.
7. Functional Performance Testing in accordance with functional performance worksheets.
8. Deficiency Report and Resolution Record.
9. Operation and Maintenance Documentation.
10. Operations and Maintenance Training.
11. Deferred Testing.

3.2 TOTAL BUILDING COMMISSIONING (TBC) REQUIREMENTS

- A. TBC during construction, acceptance, and warranty phases is intended to achieve following specific objectives:

1. Verify that systems and equipment meet Government's Project Requirements.
2. Verify equipment is what was submitted and approved.
3. Verify and document equipment is installed and started per manufacturer's recommendations, industry accepted minimum standards, and Contract Documents.
4. Verify and document equipment and systems receive complete operational checkout by installing contractors.
5. Verify and document equipment capacity and system efficiency.
6. Verify performance of building envelope. Document testing and conformance to Contract Documents.
7. Verify completeness of operations and maintenance materials.
8. Ensure Governments operating personnel are adequately trained on operation and maintenance of building equipment.

3.3 COMMISSIONING SCOPING MEETING

- A. Commissioning Scoping Meeting:

1. Schedule, coordinate, and facilitate a scoping meeting.
2. Review each building system to be commissioned, including intended operation, commissioning requirements, and completion and start-up schedules.
3. Establish scope of work, tasks, schedules, deliverables, and responsibilities for implementation of Commissioning Plan.
4. Attendance: Commissioning Team members.

3.4 COMMISSIONING PLAN

- A. Commissioning Plan: Develop commissioning plan to identify how commissioning activities will be integrated into general construction and trade activities. Commissioning plan shall identify how commissioning responsibilities are distributed. Intent of plan is to evoke questions, expose issues, and resolve issues with input from entire commissioning team early in construction.
 - 1. Identify who will be responsible for producing various procedures, reports, Contracting Officer notifications and forms.
 - 2. Include commissioning tasks and activities in overall Project schedule. Tag individual activities so they can be filtered at later date.
 - 3. List and describe each test/acceptance procedure, including acceptance criteria.

3.5 START-UP/PRE-FUNCTIONAL CHECKLISTS

- A. Start-Up/Pre-Functional Checklists: Complete pre-functional checklists prior to start up. Checklist shall help verify that systems are complete and operational, so functional performance testing can be scheduled.
 - 1. Verify equipment installed is what was approved on Submittal.
 - 2. Manufacturer's start-up checklists and other technical documentation guidelines may be used as basis for pre-functional checklists.

3.6 FUNCTIONAL PERFORMANCE TESTING

- A. Functional Performance Testing: Test procedures fully describe system configuration and steps required for each test.
 - 1. Test Methods: Functional performance testing and verification may be achieved by direct manipulation of system inputs (i.e. heating or cooling sensors), manipulation of system inputs with building automation system (i.e. software override of sensor inputs), trend logs of system inputs and outputs using building automation system, or short-term monitoring of system inputs and outputs using standalone data loggers. A combination of methods may be required to completely test complete sequence of operations. CCxR shall determine which method or combination of methods is most appropriate.
 - 2. Setup: Each test procedure shall be performed under conditions that simulate normal operating conditions as closely as possible. Where equipment requires integral safety devices to stop/prevent equipment operation unless minimum safety standards or conditions are met, functional performance test procedures shall demonstrate actual performance of safety shutoffs in real or closely simulated conditions of failure.
 - 3. Sampling: Multiple identical pieces of non-life-safety or non-critical equipment may be functionally tested using a sampling strategy. If, after three attempts at testing the specified sample percentage, failures are still present, remaining units shall be tested at Contractors' expense.

- B. Prepare functional performance test procedure forms to accommodate actual installed equipment and systems.
- C. Coordinate, execute, and record results of functional performance testing.
 - 1. Coordinate retesting as necessary until satisfactory performance is verified.
 - 2. Verify intended operation of individual components and system interactions under various conditions and modes of operation.

3.7 DEFICIENCY REPORT AND RESOLUTION RECORD

- A. Deficiency Report and Resolution Record: Document items of non-compliance in materials, installation or operation.
- B. Non-Conformance: Non-conformance and deficiencies observed shall be addressed immediately. Notify responsible parties and provide recommended actions to correct deficiencies.
 - 1. Corrections of minor deficiencies identified may be made during tests at discretion of CCxR. In such cases the deficiency and resolution shall be documented on procedure form.
 - 2. For Identified Deficiencies:
 - a. If no dispute on deficiency and responsibility to correct it:
 - 1) CCxR documents deficiency and adjustments or alterations required to correct it. Contractor corrects deficiency and notifies CCxR that equipment is ready to be retested.
 - 2) CCxR reschedules test and test is repeated until satisfactory performance is achieved.
 - b. If there is a dispute about a deficiency or who is responsible:
 - 1) Deficiency is documented CCxR on non-compliance form.
 - 2) Resolutions are made at lowest management level possible. Additional parties are brought into discussions as needed. Contractor shall have responsibility for resolving construction deficiencies. If a design revision is deemed necessary and approved by Contracting Officer, Architect/Engineer (A/E) shall have responsibility for providing design revision. CCxR documents resolution process.
 - 3) Once interpretation and resolution have been decided, appropriate party corrects deficiency and notifies CCxR that equipment is ready to be retested. CCxR reschedules test and test is repeated until satisfactory performance is achieved.
 - 3. Cost of Retesting: Costs for retesting shall be charged to Contractor.

3.8 OPERATIONS AND MAINTENANCE TRAINING

- A. Training: Develop Training Plan. Coordinate and execute training programs with CxA.
1. Stress and enhance importance of system interactions, troubleshooting, and long-term preventive maintenance and operation programs.

3.9 DEFERRED TESTING

- A. Unforeseen Deferred Tests: If test cannot be completed due to building structure, required occupancy condition, or other deficiency, functional testing may be delayed upon recommendation of CCxR and approval of Contracting Officer. These tests are conducted in same manner as the seasonal tests, as soon as possible.
- B. Seasonal Testing:
1. Schedule, coordinate, execute, and document additional testing for seasonal variation in operations and control strategies during appropriate season to verify performance of HVAC system and controls. Complete testing during warranty period to fully test sequences of operation.
 2. Update O&M manuals and Project Record Drawings as necessary due to testing.

3.10 EQUIPMENT & SYSTEM SCHEDULE

- A. Commissioned Equipment and Systems List: Following is a list of systems and equipment to be commissioned organized by system. It includes the percentage of each category that will undergo testing. The intent is to provide an overall summary of commissioned equipment and systems, and not a comprehensive list. Refer to applicable specification sections for more information.

COMMISSIONED EQUIPMENT AND SYSTEMS LIST			
SYSTEM	EQUIPMENT	CC (Commissioning Coordinator)	FPT (Functional Performance Test)
HVAC Make-Up air Units	Make-up air units at Facilities 20, 32, 80		X
HVAC Dedicated Outdoor Air Units	Dedicated outdoor air units at Facility 10		X
HVAC Split System Heat Pump Units	Split system air conditioning units at Facilities 10, 20, 32, 80		X
HVAC Heat Pump Units	Packaged heat pump at Building 12		X
HVAC Exhaust Fans	Exhaust fans at Facilities 10, 12, 20, 32, 80		X

