

**SECTION 17900**  
**BUILDING COMMISSIONING**

**PART 1 - GENERAL**

**1.01 WORK DESCRIPTION:**

A. General:

1. The Commissioning process is a joint team effort to ensure that all mechanical equipment, controls, and systems function together properly to meet the design intent of the Engineer, and to document system performance parameters for fine-tuning of control sequences and operation procedures.
2. The Commissioning Process shall encompass and coordinate the traditionally separate functions of system documentation, equipment start-up, control system calibration, testing and balancing, training, and performance testing. Testing and balancing, controls, and training are addressed in other sections of the Specifications.
3. The Commissioning described herein is not intended to supersede or replace the normal system startup by the contracting team, observations by the design team or balancing by the Test and Balance Contractor.
4. Commissioning Process: In as much as possible, the Commissioning Process shall occur during the construction of the project for all portions of the mechanical system that are scheduled to be complete at the opening day. This is intended to:
  - a. Reduce as much as possible any duplication of work or testing for the Contractor.
  - b. Identify and solve any potential mechanical system design or construction problems as they relate to functional performance, prior to opening day.

B. Commissioning Team:

1. The commissioning team shall be made up of the:
  - a. Commissioning Authority (CSM Plant Engineering or their representative)
  - b. CSM Planning and Construction
  - c. CSM HVAC and Electrical assigned technician
  - d. Design Consultants
  - e. Construction trades including major equipment suppliers.
2. The trades represented on the commissioning team will include:
  - a. General Contractor

- b. Mechanical Contractor
  - c. Electrical Contractor
  - d. Building Management System Contractor
  - e. Fire Alarm System Contractor
  - f. Test, Adjust, and Balancing Contractor
3. The lead tradesman for each trade who will actually perform or supervise the commissioning work is to be designated as the representative to the commissioning team.
  4. Responsibility for various steps of the commissioning process will be divided among the members of the commissioning team, as described in this section.

### **1.02 RELATED DOCUMENTS**

- A. Division 1
- B. Division 15
- C. Division 16

### **1.03 DEFINITIONS:**

- A. Definition of Terms:
  1. Installation Verification: This initial portion of the Commissioning Process includes observations and punch lists recorded and performed by the Engineer to ensure that all equipment is installed in accordance with the Specifications and Drawings. The Commissioning Authority shall overview this process.
  2. Pre-functional Testing: This portion of the Commissioning Process involves primarily the test and balance and startup personnel to ensure that individual pieces of equipment are capable of performing in accordance with the Specifications, Drawings, and manufacturers' requirements. This is documented with a pre-functional checklist provided and completed by the Contractor. The Commissioning Authority shall overview this testing.
  3. Functional Performance Testing: This portion of the Commissioning Process involves dynamic tests that ensure that all mechanical systems function in accordance with design intent. The tests are dynamic and on-line and test the systems through all possible modes of operation.
  4. Calibration: To check or adjust the graduations of a quantitative measuring instrument against a known standard.
  5. Adjustment: To change the speed, flow, position, signal, or level of any piece of mechanical equipment.
  6. Tuning: To adjust for maximum performance.

7. Minor Adjustment: To add, subtract, or change various parameters included in the operation logic of a mechanical system or systems in order to improve or optimize operational performance. This refers only to the specified performance logic. Difficulties encountered in accomplishing a minor adjustment shall not be used to define a minor versus a major adjustment.
8. Major Adjustment: To fully change the specified operation logic of a mechanical system or systems. This refers only to the specified performance logic. Difficulties encountered in accomplishing a minor adjustment shall not be used to define a minor versus a major adjustment.
9. System Component or System Element: A single piece of mechanical equipment such as a pump, fan, chiller, boiler, coil, etc. that when combined together through piping or ductwork will comprise a "System".
10. System: A combination of system components that allow the manufacture or distribution of conditioned air or water from one location to another.

#### **1.04 COMMISSIONING RESPONSIBILITIES**

##### **A. Commissioning Authority Responsibilities:**

1. Coordinate and direct each step of the commissioning process, and recommend acceptance or non-acceptance to the Owner.
2. Assist in clearly identifying problems encountered in testing the functional performance of the mechanical system and cooperatively assist in the development of the solutions to those problems. These potential problems may include mechanical design, mechanical installation, mechanical equipment, controls devices, controls installation, controls software, etc. The commissioning Authority shall be competent to review and understand the software code developed by the Controls Contractor.
3. Coordinate directly with each subcontractor with respect to their responsibility and contractual obligations.
4. Obtain, assemble and submit commissioning documentation.
5. Attend periodic on-site commissioning activities.
6. Develop the commissioning plan and schedule.
7. Develop the commissioning checklists and functional performance test plans. If there is a conflict between the requirements of the Engineer and those of the Commissioning Authority, and the conflict cannot be resolved, the requirements of the Engineer shall have precedence.
8. Coordinate the installation verification inspections.
9. Review the controls documentation and interface with other systems.

10. Review the operation and maintenance information and as-built drawings provided by the various subcontractors and vendors.
  11. Note any inconsistencies or deficiencies in the system.
  12. Enforce system compliance and recommend modifications to the system design that will correct or enhance the system performance.
  13. Coordinate the Owner witnessing of the tests.
  14. Be present during start-up activities to assist and witness the execution of startup.
  15. Monitor the performance of the Test, Adjust and Balance Contractor.
  16. Review the accuracy and calibration of any instrumentation utilized for the functional performance testing.
  17. Direct the functional performance testing.
  18. Track commissioning deficiencies until correction.
  19. Prepare and submit the Commissioning Reports.
  20. Assemble and submit the final Commissioning Report.
  21. In the event that any one of the Contractors or Engineers are unwilling or unable to participate in the commissioning process and/or the resolution of problems identified in the commissioning process, that portion of the commissioning process shall be discontinued until such time that Contractor/Designer participation and problem resolution is resumed. The Commissioning Authority shall notify the Owner's Representative in writing of:
    - a. The portion of the commissioning process in question.
    - b. The problem being encountered with the system.
    - c. The problem being encountered with the Contractor/Designer.
    - d. The approximate costs encountered in attempting to get cooperation and projected costs in completing that portion of the commissioning process.
- B. Smoke Management System Commissioning Authority Responsibilities:
1. Inspect the following:
    - a. Automatic Dampers
    - b. Fans
    - c. Control Diagrams
    - d. Marking & Identification

2. Verify the following
    - a. Vestibules
    - b. Fans
    - c. Detection Devices
    - d. Dampers
    - e. Inlets and Outlets
    - f. Smoke Barriers
    - g. Standby Power
    - h. Control Action and Priorities
    - i. Controls
    - j. Response Time
  3. Reports: Provide the following reports and forms:
    - a. Verification Plan
    - b. Testing and Validation Forms
    - c. Daily Log and Report Forms
    - d. Non-Compliance Forms
- C. Design Engineer Responsibilities:
1. Observations and checklists for Installation Verification as defined in Part 2 of this specification.
  2. Additional calculation and investigation of design adjustments needs by the Engineers as defined by the Commissioning Authority.
  3. Participation in the resolution of potential design concerns as discovered during the commissioning process.
- D. Contractor Responsibilities:
1. Pre-functional Testing, a start-up procedure performed prior to balancing as defined in Part 2 of this specification.
  2. Providing any technical personnel required for physical operation, testing, and simulation of control sequences for each piece of controlled equipment as required by the Commissioning Authority during the Functional Performance Testing. This shall include chiller service personnel, boiler service personnel, the temperature control engineering and technical startup crew, mechanical contracting service personnel for miscellaneous mechanical equipment, and balancing contractor personnel. To the extent possible, these personnel will be scheduled.
  3. Additional calibration and adjustment of the mechanical equipment included in each mechanical system for proper

operation under actual operation as defined by the Commissioning Authority.

4. Additional testing, calibration, adjustment, tuning, and minor adjustments to the temperature controls system sequences for proper operation under actual operation as defined by the Commissioning Authority. Additional testing, calibration and adjustment of the mechanical water and air flows of each mechanical system for proper operation under actual operation as defined by the Commissioning Authority.

## **PART 2 - COMMISSIONING PROCESS**

### **2.01 GENERAL**

- A. Scope Meeting: Early in the construction process, a commissioning scope meeting involving all members of the commissioning team shall be held at a time and place designated by the Owner. The purpose of the meeting will be to familiarize all parties with the requirements of the commissioning process, and to ensure that the responsibilities of each party are clearly understood.
- B. Progress Meetings: The Commissioning Authority shall conduct monthly commissioning meetings during the initial 75% of the project. During the final 25% of the project construction, the Commissioning Authority shall conduct weekly meetings.
- C. During all meetings, the meeting minutes shall be recorded and distributed to the Owner and all concerned parties in a timely manner. Responsibility for meeting minute recording and distribution shall be determined during the scope meeting.

### **2.02 SYSTEM START-UP AND TESTING**

- A. General Requirements:
  1. All systems and system components shall be tested in presence of Commissioning Authority (and the Engineer if desired by the Engineer) to demonstrate compliance with specified requirements. To minimize the time of commissioning, contracting, and engineering team members, testing shall be done in seasonal single blocks of time insofar as possible.
  2. The Contractor shall notify the Commissioning Authority fourteen (14) days prior to scheduled Functional Performance Tests, of the scheduled completion date of the Installation Verification and Pre-functional Testing.
  3. All testing shall be conducted under specified design operating conditions as approved by Commissioning Authority and Engineer.

4. All elements of systems shall be tested to demonstrate that total systems satisfy all requirements of these Specifications. Testing shall be accomplished on hierarchical basis. Each piece of equipment shall be tested for proper operation, followed by each subsystem, followed by entire system, followed by any inter-ties to other major systems.
5. All special testing materials and equipment shall be provided by Contractor. This includes, but is not limited to, proprietary equipment, hand-held control parameter/setpoint adjustment tools, and water/air flow balancing readout and adjustment tools.
6. One copy of all test reports and records shall be provided to Commissioning Authority.

B. Test Procedure Development and Test Documentation:

1. Within sixty (60) days prior to startup of the mechanical system, the Commissioning Authority shall prepare and submit to the Owner's Representative and Engineer for review, descriptions of the test procedures, which the Contractor will perform to demonstrate conformance of completed mechanical systems to the Plans and Specifications.
2. The decision of the Commissioning Authority and Engineer upon acceptability of test procedures shall be final. In the event of irresolvable conflict between the decisions of Commissioning Authority and Engineer, Engineer's decision shall have precedence. However, in no case shall such decision excuse the Contractor from fulfilling the requirements of commissioning as described in this Section.

C. Installation Verification Recommendations:

1. All systems and system components shall be checked and verified that they have been installed according to the drawings and specifications, and that all connections have been made correctly.
2. Each system of interactive system components shall be observed and verified that it is ready to function as specified.
3. Verification of complete and proper installation shall be completed prior to starting Component Performance Tests.
4. The Installation Verification shall be documented in a checklist format for each system/piece of equipment. Each checklist shall be dated and initialed by the Engineer.

D. Pre-functional Testing Requirements:

1. Each system component shall be checked for proper installation, shall be adjusted, and shall be calibrated to verify that it is ready

to perform as specified.

2. All system components shall be checked to verify that they have been installed properly and that all connections have been made correctly. Verification shall be completed that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence or other conditions, which may cause damage.
3. Verification shall be completed that test, meter readings and specific electrical characteristics agree with those required by equipment or system manufacturer.
4. All discrete elements and sub-systems of system components shall be adjusted and shall be checked for proper operation. Verification shall be completed that wiring and support components for equipment are complete and tested.
5. Verification of complete and proper installation shall be completed prior to starting Functional Performance Tests.
6. The Pre-functional Tests shall be documented in a checklist format for each system and each piece of equipment. Each checklist shall be dated and initialed by the Contractor.

E. Functional Performance Testing Requirements:

1. A Functional Performance Test shall be performed on each complete system. Each function shall be demonstrated to the satisfaction of the Commissioning Authority on a paragraph-by-paragraph basis of the written test procedure, developed to demonstrate conformance to requirements of contract Specifications and the Design Intent Document.
2. Each Functional Performance Test shall be witnessed and signed off by the Commissioning Authority, Contractor, and Owner's Representative (and Engineer if requested) upon satisfactory completion.
3. The Functional Performance Testing Program shall be conducted in accordance with prior approved procedures and shall be documented as required hereinafter.
4. The Commissioning Authority shall notify the contracting team, CSM Planning and Construction, the Architect, and the Engineer at least two weeks prior to date of scheduled Functional Performance Tests. The seasonal Functional Performance Test periods shall be scheduled over a single block of days. The schedule of the Functional Performance Tests shall be based on the construction completion schedule.



## **2.03 REPORTS**

### **A. Documentation - General:**

1. The Commissioning Authority shall record and maintain detailed testing data. The data record shall be comprehensive and concise.
2. All data must be recorded as soon as possible during the course of the testing.
3. All documentation shall have the date and time, and the names of persons participating in the inspection and testing.
4. All test instruments shall be documented for valid calibration.
5. The recording work sheets, inspection checklists, and performance testing plans must all be approved by the Engineer, Owner and Commissioning Authority prior to the start of Functional Performance Testing.

### **B. Daily Commissioning Report Logs:**

1. The Commissioning Authority shall provide daily report logs to be included in the final report.
2. The daily logs shall record the Commissioning Authority personnel and event summaries of meetings, conversations, tests, failures, solutions, procedures and successes.

### **C. Functional Performance Test Plans, Tables and Checklists:**

1. The Commissioning Authority shall prepare detailed test plans with associated checklists to organize and document the Functional Performance Testing.
2. A separate test plan is required for each device or control sequence.
3. A separate checklist is required for each of the equipment/systems. The sample test plan and checklist in part B and C of this section of the specifications, below, is provided as an example of the level of detail and logical approach required in the System Performance test checklists.
4. Provide testing tables for large quantities of repetitive test events such as outside air volumes, VAV box close-offs, valve close-offs, etc.

### **D. Final Report:**

1. The Commissioning Agent shall prepare and submit to the Owner's Representative a final report after completion of the commissioning.
2. The report shall verify performance of HVAC equipment and systems.

3. Any field modifications to the testing process, and why these modifications were made, shall be documented.
4. The organization of the final mechanical systems commissioning report shall be as follows:
  - a. Executive Summary of each mechanical system and problems encountered and resolved.
  - b. System Overview summarizing the system design.
  - c. Commissioning Plan
  - d. Post Commissioned Controls Sequences and Points Lists.
  - e. Pre-functional Testing Checklists
  - f. Functional Testing Procedures and Results
  - g. Smoke Control Testing Scenarios and Results
  - h. Appendix of letters, memo and notes occurring during the commissioning process.

## **PART 3 - EXECUTION**

### **3.01 GENERAL**

- A. The Functional Performance Testing portion of the commissioning process shall begin after the installation of the HVAC equipment and systems, along with related equipment, systems, structures, and areas are complete.

### **3.02 INSTALLATION VERIFICATION TESTING**

- A. All installation verification and observations tasks shall be performed as outlined under the contractual consultant design service agreements.

### **3.03 PRE-FUNCTIONAL TESTING**

- A. All component performance test tasks shall be as described in the specifications under general or specific equipment startup procedures and requirements, and under the test and balance requirements.

### **3.04 FUNCTIONAL PERFORMANCE TESTING**

- A. Mechanical System Tasks: Verify that the total HVAC mechanical system is performing to provide conditions through all possible modes of operation as outlined in the Design Intent Document (provided by the Engineer). The Functional Performance Testing procedures shall statistically represent all operating characteristics of all mechanical equipment and systems, including:
  1. Air handling and ventilation systems operation including exhaust

- fans, heat pumps, and fancoils.
  - 2. Chilled water system operation including chillers, pumps, and controls.
  - 3. Condenser water system operation including cooling towers, pumps, and controls.
  - 4. Heating water or steam system operation including boilers, pumps, and controls.
  - 5. Ventilation systems operation including air handling systems, exhaust fans, supply fans, makeup air systems, and controls.
  - 6. Terminal unit operation such as variable air boxes, fancoils, and heat pumps.
  - 7. Pressurization system operation.
- B. Building Automation System Tasks: Verify that the total building automation system control system is performing to provide conditions through all possible modes of operation as outlined in the Design Intent Document (provided by the Engineer). The Functional Performance Testing procedures shall address all operating characteristics of a statistical representation of control system equipment, sequences, and instrumentation calibration including:
- 1. Chilled water system operation.
    - a. Test all points and modes.
  - 2. Condenser water system operations.
    - a. Test all points and modes.
  - 3. Heating water and steam system operation.
    - a. Test all points and modes.
  - 4. Air handling and ventilation systems operation.
    - a. Test all modes for 20% of units.
    - b. Test all systems for specific identified problems uncovered during the testing (i.e. valve close-off).
  - 5. Terminal unit operation such as variable air boxes, fancoils, and heat pumps.
    - a. Test all modes for 10% of units.
    - b. Test all systems for specific identified problems (i.e. VAV box close-off).
  - 6. Exhaust fans systems.
    - a. Test all modes for 20% of systems.

7. Pressurization Systems.
  - a. Test all points and modes.
- C. Test and Balance (TAB) Tasks: Verify TAB readings for the approximate quantities of the following:
  1. 50% of fan flows.
  2. 50% of pump flows.
  3. 50% of outside air volumes.
  4. 50% of equipment pressure drops.
  5. 10% of the supply (maximum and minimum primary air) return and exhaust diffusers, registers, and grilles.
  6. 10% of hydronic flows.
  7. 10% of balancing valve/damper settings.
  8. 10% of VAV box setups.
  9. 10% of coil pressure drops.
  10. If more than one-fifth of these readings differ from the documented TAB readings by more than 15 percent, then the TAB for the failed system shall be repeated in entirety.

### **3.05 TRAINING**

- A. The Commissioning Authority shall conduct a customized three- to five-day training class for facility engineering personnel in problem-solving techniques with respect to the commissioned installation. This Commissioning Authority training does not reduce or exclude the training specified in other specification sections, although portions of other specified training may be included as a part of the Commissioning Authority training. This problem-solving class shall focus on the following:
- B. Present the mechanical system design as a whole integrated unit.
  1. Point out the unique qualities of the installed mechanical system.
  2. Provide insights into how to solve system-wide, multi-faceted problems.
  3. Identify a variety of resources available to assist with problem solving.
  4. The problem-solving class is not intended teach day-to-day maintenance of parts and/or systems, establish emergency procedures, or problem solving approaches.
- C. Typical Mechanical Systems Problem-Solving Training Agenda:
  1. Opening Remarks and Introductions
  2. Description and evolution of the mechanical system design

concepts specific to the project.

3. Description and overview of airside and waterside HVAC systems provided in the project.
4. Instruction on the Air Handling Systems.
  - a. Operation of the systems.
  - b. Delivery of the conditioned air to the spaces.
  - c. Referencing associated and available documentation.
  - d. Problem-solving lab.
5. Instruction on the Mechanical Cooling Systems.
  - a. Operation of the system.
  - b. Referencing associated and available documentation.
  - c. Problem-solving lab.
6. Instruction on the Heating Systems.
  - a. Operation of the system.
  - b. Referencing associated and available documentation.
  - c. Problem-solving lab.
7. Instruction of miscellaneous systems.
  - a. Operation of the system.
  - b. Referencing associated and available documentation.
  - c. Problem-solving lab.
8. Overview of all mechanical subsystems as one large system.
  - a. Problem-solving lab for all systems.

### **3.06 SYSTEM ACCEPTANCE**

- A. Mechanical and electrical systems will be considered acceptable upon completion of commissioning punch list items.
- B. As-Built Documentation: After a successful acceptance demonstration, the Contractor shall submit as-built drawings of the completed project for final approval. After receiving final approval, supply six (6) complete as-built drawing sets, together with AutoCAD diskettes to the Owner.
- C. Operation and Maintenance Manuals: Submit three (3) copies of operation and maintenance manuals. Include the following in each manual:
  1. Manufacturer's catalog data and specifications on all sensors, transmitters, controllers, control valves, damper actuators, gauges, indicators, terminals, and any miscellaneous components used in the system.

2. An Operator's Manual, which will include detailed instructions for all operations of the system.
3. An Operator's Reference Table listing the addresses of all connected input points and output points. Settings shall be shown where applicable.
4. A Programmer's Manual, which will include all information necessary to perform programming functions.
5. A language manual which will include a detailed description of the language used and all routines used by the system.
6. Flow charts of the control software programs utilized in the Temperature Control System.
7. Flow charts of the custom software programs utilized in the Temperature Control System.
8. Complete program listing file and parameter listing file for all programs.
9. Field as-built wiring diagram.
10. A copy of the warranty.
11. Operating and maintenance cautions and instructions.
12. Recommended spare parts list.

### **3.07 TRAINING**

- A. BAS manufacturer shall provide to the Engineer a training class outline prior to any scheduled training.
- B. Training sessions shall be provided for the Owner's personnel by factory-trained control engineers and technicians.
- C. The BAS Contractor shall conduct two (2) eight-hour training courses for the designated Owner's personnel in the maintenance and operation of the control system. One class shall be given upon system acceptance and the other approximately six months after the warranty commences. The courses shall include instruction on specific systems and instructions for operating the installed system to include as a minimum:
  1. HVAC system overview.
  2. Operation of Control System.
  3. Function of each Component.
  4. System Operating Procedures.
  5. Programming Procedures.
  6. Maintenance Procedures.
- D. In addition to the training required above, the BAS manufacturer shall make all factory training courses routinely available (including those conducted for the manufacturer's own engineers, technicians and

representatives) to the Owner's personnel. Evidence of the routine availability of such courses shall be presented with the submittals.

### **3.08 WARRANTY**

- A. Warranty: The entire control system shall be warranted to be free from defects in both materials and workmanship for a period of one (1) year of normal use and service. Control valves shall have a two (2) year warranty. Warranties shall become effective with Beneficial Use or on the date the Owner accepts the system, whichever is sooner.
- B. An emergency service number shall be provided to the owner. Response shall be within four (4) hrs. to the phone call.

## **PART 4 OPERATIONS**

### **4.01 GENERAL**

- A. All HVAC Systems shall be controlled with Direct Digital Control (DDC) (according to the point list, sequences of operation, and control diagrams shown on the drawings) and shall be stand-alone. Additional points or software programming not listed or shown, but which are required to meet the sequences of operation, shall be provided.
- B. All controllers, relays, transducers, etc., required for stand-alone control shall be housed in NEMA and UL listed enclosures with a lockable door. The type of NEMA enclosure shall be based upon environmental requirements outlined in the specifications or on the drawings for this project.

END OF SECTION