

## SECTION 230800 COMMISSIONING OF HVAC

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, General Commissioning Requirement and other Division 01 Specification Sections, apply to this section.
- B. The OPR and BOD documentation are included by reference for information only.
- C. Division 01 section LEED v4 BD+C for additional LEED requirements.

#### 1.2 SUMMARY

- A. This section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. Related Sections:
  - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.
  - 2. Division 23 Heating Ventilation & Air Conditioning

#### 1.3 DESCRIPTION

- A. Commissioning: Commissioning is a systematic process of verifying that all building systems, including the mechanical and electrical systems, have been installed in the prescribed manner, are functionally checked and capable of being operated and maintained to perform with the design intent and have documentation to support proper installation and operation. The Commissioning Agent (CxA) shall provide the Owner with an unbiased, objective view of the system's installation, operation and performance. This process does not eliminate or reduce the responsibility of each system designer to provide a complete design or installing subcontractors to provide a finished product. Commissioning is intended to enhance the quality of each system installation, startup and transfer to beneficial use by the Owner.
- B. Commissioning during the construction phase is intended to achieve the following specific objectives, according to the Contract Documents:
  - 1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
  - 2. Verify and document proper performance of equipment and systems as per the written procedures.
  - 3. Verify that Operation & Maintenance documentation is complete and transferred to Owner.
  - 4. Verify that proper orientation program has been implemented for the Owner's operating personnel.

5. Verify a contract is in place for a post occupancy review with O&M staff within 10 months after Substantial Completion.
- C. The Commissioning process shall be a team effort and encompass, as well as coordinate, the traditionally separate functions of system documentation, system installation, equipment startup, control system calibration, testing, balancing and verification and performance checkouts.
- D. The CxA will work closely with the construction team, cooperating on and coordinating all Cx activities with the CM and/or Owner's representative, Trade Contractors, subcontractors, manufacturers and equipment suppliers.

The Cx process shall not reduce the responsibility of the CM and or the contractor to comply with the Contract Documents.

#### 1.4 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

#### 1.5 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to contract document for specific submittal requirements.
- C. In addition, provide the following:
  1. Certificates of readiness
  2. Certificates of completion of installation, pre-start, and startup activities.
  3. O&M manuals
  4. Field / factory test reports
- D. Control Drawings Submittal
  1. The control drawings shall have a key to all abbreviations.
  2. The control drawings shall contain graphic schematic depictions of the systems and each component.
  3. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
  4. Provide a full points list with at least the following included for each point:
    - a. Controlled system
    - b. Point abbreviation
    - c. Point description
    - d. Display unit
    - e. Control point or set point (Yes / No)
    - f. Monitoring point (Yes / No)
    - g. Intermediate point (Yes / No)
    - h. Calculated point (Yes / No)

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

**PART 2 - PRODUCTS**

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC&R system and controls system in Division 23, except for equipment specific to and used by TAB contractor in their commissioning responsibilities. A sufficient quantity of two-way radios shall be provided by each subcontractor, as necessary.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. If required and necessary, data logging equipment and software required for testing will be provided by the CxA, but shall not become the property of the Owner.
- E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°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.

**PART 3 - EXECUTION**

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Pre-Functional/Installation Checklists for commissioned components, equipment, and systems

- B. Shop Drawings (including red-line drawings):
  - 1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on shop drawings.
  - 2. Preliminary shop drawings will be made available to the Commissioning Team for use to generate Prefunctional Checks and should be submitted prior to the start of Functional Performance Testing.
  - 3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
  - 4. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. Operation and Maintenance Data:
  - 1. Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
  - 2. The CxA will review the O&M literature once for conformance to project requirements.
  - 3. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the Contractor.
- D. Testing, Demonstration and Orientation:
  - 1. Contractor will provide demonstration and operator's orientation program as required by the contract document.
  - 2. A complete orientation program and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any such event.
  - 3. Agenda for each orientation session shall be submitted to the CxA at least one (1) week prior to the session.
  - 4. The CxA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CxA and Owner's representative. A copy of the test record shall be provided to the CxA, Owner, and Architect.
  - 5. Engage a Factory-authorized service representative to demonstrate Owner's maintenance personnel to adjust, operate, and maintain specific equipment.
  - 6. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining equipment.
  - 7. Review and update data in O&M Manuals.

### 3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Mechanical, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors of Division 23 are as follows (all references apply to commissioned equipment/systems only):
- B. Perform commissioning tests at the direction of the CxA.
- C. Attend construction phase controls coordination meetings.

- D. Attend testing, adjusting, and balancing review and coordination meetings.
- E. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- F. Provide information requested by the CxA for final commissioning documentation.
- G. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- H. Prepare preliminary schedule for Mechanical system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.
- I. Update schedule as required throughout the construction period.
- J. During the startup and initial checkout process, execute the related portions of the prefunctional/installation checklists for all commissioned equipment.
- K. Assist the CxA in all verification and functional performance tests.
- L. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- M. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA (45) days after submittal acceptance.
- N. Coordinate with the CxA to provide (72) hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- O. Notify the CxA a minimum of (2) weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.
- P. Participate in, and schedule vendors and contractors to participate in the operator's orientation sessions.
- Q. Provide written notification to the CM/GC and CxA Authority that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
  - 1. HVAC&R equipment including all fans, air handling units, piping, ductwork, dampers, terminals, and all other equipment furnished under this Division.
  - 2. Controls system used for equipment monitoring and manipulation
  - 3. Fire stopping in the fire rated construction, including fire and smoke damper installation, caulking, gasketing and sealing of smoke barriers.
  - 4. Fire detection and smoke detection devices furnished under other divisions of the specification.
- R. The equipment supplier shall document the performance of his equipment.
- S. Test, Adjust and Balance Contractor
  - 1. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.

2. Submit the site specific testing and balancing plan to the CxA and AE for review and acceptance.
  3. Attend the testing and balancing review meeting scheduled by the CM. Be prepared to discuss the procedures that shall be followed in testing, adjusting, and balancing the HVAC&R system.
  4. At the completion of the testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R contractor and the CM/GC.
  5. Participate in verification of the testing and balancing report, which will consist of repeating measurements contained in the testing and balancing reports. Assist in diagnostic purposes when directed.
- T. Equipment Suppliers
1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
  2. Assist in equipment testing per agreements with contractors.
  3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
- U. Refer to Division 01 Section “General Commissioning Requirements” for additional contractor responsibilities.

### 3.3 OWNER’S RESPONSIBILITIES

- A. Refer to Division 01 Section “General Commissioning Requirements” for Owner’s Responsibilities.

### 3.4 CxA RESPONSIBILITIES

- A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s Responsibilities.

### 3.5 TESTING PREPARATION

- A. Certify in writing to the CxA that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify in writing that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

### 3.6 TESTING, ADJUSTING AND BALANCING VERIFICATION

- A. Air and water testing, balancing and equipment performance verification shall be accomplished by an independent test and balance firm. The CxA shall spot check this work to verify accuracy of results.
- B. Prior to performance of Testing, Adjusting and Balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
- C. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.
- D. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.
  - 1. The CxA will notify testing and balancing subcontractor ten (10) days in advance of the date of field verification. Notice will not include data points to be verified.
  - 2. The testing and balancing subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
  - 3. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

### 3.7 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include verification of dynamic operation of the system.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The CxA along with the HVAC&R contractor, testing and balancing Subcontractor, and HVAC&R Instrumentation and Control Subcontractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct to alter set points when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

- I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

### 3.8 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. **Equipment Testing and Acceptance Procedures:** Testing requirements are specified in individual Division 23 sections. Provide submittals, test data, inspector record, and certifications to the CxA.
- B. **HVAC&R Instrumentation and Control System Testing:** Field testing plans and testing requirements are specified in Division 23 Sections. Assist the CxA with preparation of testing plans.
- C. **Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment:** Test requirements are specified in Division 23 piping Sections. HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include but not limited to the following:
  - 1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
  - 2. Description of equipment for flushing operations.
  - 3. Minimum flushing water velocity.
  - 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
- D. **Refrigeration System Testing:** Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- E. **HVAC&R Distribution System Testing:** Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.
- F. **Vibration and Sound Tests:** Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.
- G. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
  - 1. HVAC systems
  - 2. Building Automation System

3. Ductwork and accessories
4. Testing, Adjusting and Balancing

3.9 APPROVAL

- A. Refer to other specification and “General Commissioning Requirements” for approval procedures.

3.10 DEFERRED TESTING

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.11 OPERATION AND MAINTENANCE MANUALS

- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.
- B. Refer to Division 01 Section “General Commissioning Requirements” for the CxA roles in the Operation and Maintenance Manual contribution, review and approval process.
- C. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.

3.12 OWNER OPERATING PERSONNEL ORIENTATION

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.
- B. Mechanical Contractor. The mechanical contractor shall have the following training responsibilities:
  1. Provide the CxA with a training plan two weeks before the planned training.
  2. Provide designated Owner’s personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, all HVAC equipment (ex. pumps, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls and water treatment systems, etc.)
  3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
  4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
  5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.
  6. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
  8. Training shall include:
    - a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
    - b. Discussion of relevant health and safety issues and concerns.
    - c. Discussion of warranties and guarantees.
    - d. Common troubleshooting problems and solutions.
    - e. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
    - f. Discussion of any peculiarities of equipment installation or operation.
    - g. The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1-2019, is recommended.
  9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
  10. The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
  11. Training shall occur after functional testing is complete, unless approved otherwise by the Owner.
- C. Controls Contractor. The controls contractor shall have the following training responsibilities:
1. Provide the CxA and AE with a training plan four weeks before the planned training.
  2. The controls contractor shall provide designated Owner personnel training on the control system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the control system.
  3. Training manuals. The standard operating manual for the system and any special training manuals will be provided for each trainee, with three extra copies left for the O&M manuals. In addition, copies of the system technical manual will be demonstrated during training and three copies submitted with the O&M manuals. Manuals shall include detailed description of the subject matter for each session. The manuals will cover all control sequences and have a definitions section that fully describes all relevant words used in the manuals and in all software displays. Manuals will be approved by the CxA and A/E. Copies of audiovisuals shall be delivered to the Owner.
  4. The trainings will be tailored to the needs and skill-level of the trainees.
  5. The trainers will be knowledgeable on the system and its use in buildings. For the on-site sessions, the most qualified trainer(s) will be used. The Owner shall approve the instructor prior to scheduling the training.

6. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
7. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
8. Three (3) training sessions are suggested:
  - a. Training I. Control System. The first training shall consist of 8 hours of actual training. This training may be held on-site or in the supplier's facility. If held off-site, the training may occur prior to final completion of the system installation. Upon completion, each student, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
  - b. Training II. Building Systems. The second session shall be held on-site for a period of 8 hours of actual hands-on training after the completion of system commissioning. The session shall include instruction on:
    - 1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems, lighting controls and any interface with security and communication systems.
    - 2) Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing set points and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
    - 3) All trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.
    - 4) Every screen shall be completely discussed, allowing time for questions.
    - 5) Use of keypad or plug-in laptop computer at the zone level.
    - 6) Use of remote access to the system via phone lines or networks.
    - 7) Setting up and changing an air terminal unit controller.
    - 8) Graphics generation
    - 9) Point database entry and modifications
    - 10) Understanding DDC field panel operating programming (when applicable)
  - c. Training III. The third training will be conducted on-site six months after occupancy and consist of 8 hours of training. The session will be structured to

address specific topics that trainees need to discuss and to answer questions concerning operation of the system.

- D. TAB: The TAB contractor shall have the following training responsibilities:
1. TAB shall meet with facility staff after completion of TAB and instruct them on the following:
    - a. Go over the final TAB report, explaining the layout and meanings of each data type.
    - b. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
    - c. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
    - d. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
    - e. Other salient information that may be useful for facility operations, relative to TAB.

END OF SECTION 230800