

SECTION 23 08 00 - COMMISSIONING OF HVAC

PART I - GENERAL

1.1 DESCRIPTION *[By AE]*

- A. Commissioning shall be done in accordance with ASHRAE 90.1, 6.7.2.4. System Commissioning.

1.2 HEATING, VENTILATING, BUILDING AUTOMATION SYSTEMS (BAS), AND TAB WORK *[Note to AE: Contract Documents shall require clearly defined responsibility.]*

- A. The commissioning tasks applicable to the mechanical, BAS and TAB work of Division 23 are as follows (all references apply to equipment to be commissioned only):
 1. Construction and Acceptance Phase Requirements
 - a. Submittal data, commissioning documentation, O&M data and training.
 - b. Attend all commissioning meetings.
 - c. Provide shop drawings of equipment to be commissioned along with completed & signed Pre-Functional checklists.
 - d. Document start-up and functional testing procedures including.
 - 1) Manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, Owner-contracted tests, fan and pump curves, all factory testing reports, and all warranty information.
 - 2) The Owner will require additional documentation necessary for LEED submittals if required by USGBC.
 - e. Table of Contents with listing of all equipment that will be included in the O&M manuals for review and approval.
 - f. Specific functional performance test procedures.
 - g. Alarm limits to be used during the tests.
 - h. Start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists for all equipment to be commissioned. Submit to AE for review and approval prior to startup. Refer to *Section 01 91 13* for further details on start-up plan.
 - i. Prior to startup and initial checkout process, execute the mechanical prefunctional checklists for all equipment to be commissioned.
 - j. Perform and clearly document all system operational checkout procedures and completed startup, promptly providing a copy to the Owner as components are completed and systems are debugged and completed.
 - k. Correct all punch list items before functional testing.
 - l. Air and water TAB shall be completed with discrepancies and problems remedied before requesting Owner witnessing functional testing.
 - m. Functional Performance Tests / Procedures may be used to perform adjustments prior to witnessing by the AE and Owner.
 - n. Complete functional performance testing for specified equipment in *Section 01 91 13*. Assist the Owner in interpreting the monitoring data.
 - o. Correct deficiencies as interpreted by the *[CM/GC]* and AE and retest the equipment prior to Functional Performance Witnessing by the CxA. Coordinate scheduling of Functional Performance Witnessing with the *[CM/GC]* and Owner.

- p. Provide all Documentation, Plans, Reports, Notes, Output from Electronic Commissioning Tools / other analysis tools to the Owner promptly upon successful Functional Test witnessing.
 - q. Update O&M manuals according to the Contract Documents.
 - r. Provide training of the Owner's operating staff.
 - s. Document specific requirements to maintain the validity of the warranty.
2. Warranty Period
- a. Execute seasonal or deferred functional performance testing, witnessed by the Owner.
 - b. Correct deficiencies and make adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.
- 1.3 HEATING AND VENTILATING WORK *[Note to AE: The commissioning of Heating and Ventilating work during construction and acceptance phases shall be identified by the AE. Contract Documents shall require clearly defined responsibility.]*
- A. Provide startup for all HVAC equipment, except for the BAS system.
 - B. Assist and cooperate with the TAB contractor and Owner by:
 - 1. Include all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning.
 - 2. Include sheaves and belts that may be required by TAB.
 - 3. Provide test holes in ducts and plenums where directed by TAB to allow air measurements and air balancing. Provide an approved plug.
 - 4. Provide temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.
 - C. Prepare a preliminary schedule for Division 23 pipe and duct system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the Owner. Update the schedule.
 - D. Notify the *[CM/GC]* or Owner depending on protocol, when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the *[CM/GC]* or Owner, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the Owner has the scheduling information needed to efficiently execute the commissioning process.
- 1.4 BAS WORK *[Note to AE: The commissioning of the BAS work during construction and acceptance phases shall be identified by the AE. Contract Documents shall require clearly defined responsibility.]*
- A. Sequences of Operation Submittals. The BAS submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:
 - 1. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.
 - 2. All interactions and interlocks with other systems.
 - 3. Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
 - 4. Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included, but will generally require additional narrative).
 - 5. Start-up sequences.

6. Warm-up mode sequences.
7. Normal operating mode sequences.
8. Unoccupied mode sequences.
9. Shutdown sequences.
10. Capacity control sequences and equipment staging.
11. Temperature and pressure control: setbacks, setups, resets, etc.
12. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
13. Effects of power or equipment failure with all standby component functions.
14. Sequences for all alarms and emergency shut downs.
15. Seasonal operational differences and recommendations.
16. Initial and operational values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc., that will be useful during testing and operating the equipment.
17. Schedules, if known. (When ready to program, request Schedules from the AE if not already available).
18. To facilitate referencing in testing procedures, all sequences shall be written in small statements, each with a number for reference. For a given system, numbers will not repeat for different sequence sections, unless the sections are numbered.
19. Prior to Functional Performance Witnessing by the Owner, correct deficiencies as may be interpreted by the [CM/GC] and AE and retest the equipment. Coordinate and confirm scheduling of Functional Performance Witnessing with the [CM/GC] and Owner providing a pdf of successful trending as indication systems are ready for this procedural test phase.
20. Promptly provide all Documentation, Plans, Reports, Notes, Output from Electronic Commissioning Tools / other analysis tools to the Owner.

B. 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 setpoint
 - f. Monitoring point
 - g. Intermediate point
 - h. Calculated point
 - i. Point Description: DB temp, airflow, etc.
 - 1) Control or Setpoint: Point that controls equipment and can have its setpoint changed (OSA, SAT, etc.)

- 2) Intermediate Point: Point whose value is used to make a calculation which then controls equipment (space temperatures that are averaged to a virtual point to control reset).
 - 3) Monitoring Point: Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.
 - 4) Calculated Point: "Virtual" point generated from calculations of other point values.
- j. The Contractor shall keep the Owner informed of all changes to this list during programming and setup.
- C. The Contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing, including:
1. System name.
 2. List of devices.
 3. Procedures for testing each controller after installation.
 4. A blank copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has "passed" and is operating within the contract parameters.
 5. A description of the instrumentation, if any, required for testing.
 6. Identify what tests on what systems must be completed for TAB work. Coordinate with the Owner and TAB contractor for this determination.
- D. Assist the TAB contractor in the following manner:
1. Review the TAB plan to determine the capabilities of the building automation system toward completing TAB. Provide the TAB any needed unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.).
 2. For a given area, have all required prefunctional checklists, calibrations, startup and selected functional tests of the system debugged, completed then approved by the Owner prior to TAB.
 3. Provide a qualified technician to operate the controls during TAB, or provide sufficient training for TAB to operate the system without assistance.
 4. Provide an all points report (digital) validating commands and responses with calibrated data matching and validating the required data / Report from the TAB.
- E. Provide a signed and dated certification to the Owner and [CM/GC] upon completion of the checkout for all controlled devices, equipment and systems prior to functional testing for each piece of equipment or system, that all system programming is complete as to all respects of the Contract Documents, except functional testing requirements.
- F. Assist and cooperate with the Owner in the following manner:
- G. In addition to the control points necessary to execute all control sequences, provide monitoring, control and virtual points as required in the Contract Documents.
- H. Prior to Functional Performance Witnessing by the Owner, correct deficiencies as may be interpreted by the [CM/GC] and AE and retest the equipment. Coordinate and confirm scheduling of Functional Performance Witnessing with the [CM/GC] and Owner.
- I. Promptly provide all Documentation, Reports, Notes, Output from Electronic Commissioning Tools / other analysis tools to the Owner.
- J. List and clearly identify on the as-built duct and piping drawings, the locations of all static and differential pressure sensors (air, water and building pressure).

- K. An updated as-built version of the control drawings and sequences of operation shall be included in the final BAS O&M manual submittal.

1.5 TAB WORK. *[Note to AE: The commissioning of the TAB work during construction and acceptance phases shall be identified by the AE. Contract Documents shall require clearly defined responsibility.]*

- A. Prior to starting TAB, submit to the *[CM/GC]* the qualifications of the site technician for the project, including the name and contact information of the contractors and facility managers of recent projects the technician on which was lead. The Owner shall approve the site technician's qualifications for this project.
- B. A running log of events and issues shall be kept by the TAB field technicians. Discrepancies, deficiencies or uncompleted work by others, contract interpretation requests and lists of completed tests shall be provided to the Owner and *[CM/GC]* prior to Witness Phase of Functional Testing.
- C. Communicate in writing or during recorded meetings with the *[CM/GC]* all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect the control system setup and operation.
- D. Provide a Preliminary TAB report within two weeks of completion. A copy will be provided to the Owner. The report will contain a summary explanation of the assumptions and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC or NEBB.
- E. Provide the Owner with any requested data, gathered in accordance with the Project, but not shown on the draft reports as necessary to satisfy USGBC reporting.
- F. Conduct spot checks on all performed balancing for witness by the Owner.
- G. Provide a final electronic TAB report organized in accordance with Project requirements with details. Include all documentation previously identified and / or requested.

1.6 RELATED WORK *[By AE]*

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT *[By AE]*

PART 3 - EXECUTION

3.1 PLANS, SUBMITTALS

- A. *[Note to AE: AE shall include all relevant documentation to ensure compliance with USGBC LEED requirements. Edit Part 3 to provide TAB Plan and related submittal documentation relative to commissioning as required in this Section and Section 01 91 13.]*

3.2 STARTUP

- A. The Heating, Ventilating and BAS Work shall clarify start-up responsibility and requirements to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the Owner.
- B. Work shall identify AE responsibility for calibrating all control sensors and equipment.

3.3 CONTRACTOR TESTS

- A. Contractors shall forward to the Owner, through the *[CM/GC]*, a list and schedule of specified contractor tests. The tests shall include at least the following:

Hydronic Piping	Hydrostatic Testing Cleaning
Steam and Condensate Piping	Testing Cleaning
Ductwork	Ductwork Testing
Custom AHUs	Startup Pressure Testing
Dedicated Outside Air Unit	Startup Pressure Testing
Controls	Preparation (calibration)

- B. Unless specified otherwise, provide a minimum one week prior notice to the Owner through the [CM/GC] for each specified Contractors' test.
- C. Submit Contractors' test reports to the Owner, through the [CM/GC] within one week of the successful completion of each test. Contractors shall document and issue a test report for each required test. Individual test reports should be bundled together into a group for submission to the Owner. The test report shall contain all information required by the respective specification section including the test date, start time, stop time, test duration, initial values, final values, expected result, and acceptable test values (per individual specification sections). The person(s) conducting each test and the local code authority (if applicable) shall sign and date each test report indicating that the test has been successfully completed and the results are within acceptable parameters.

3.4 FUNCTIONAL PERFORMANCE (WITNESSED) TESTS

- A. All checkouts, coordination with other Contractors, Work, debugging, preliminary reports including validating coordinated work with BAS, Vent and Heating Contractors shall all have been completed prior to requesting scheduling of Owner witnessing of Functional Testing Procedures.

3.5 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

3.6 OPERATION AND MAINTENANCE (O&M) MANUALS

- A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications. Refer to *Section 01 78 23 – Operation and Maintenance Data* and *Section 01 91 13 – General Commissioning Requirements* for additional O&M manual requirements.
- B. Additional BAS O&M Manual Requirements. In addition to documentation that may be specified elsewhere, the BAS Contractor shall compile and organize at minimum the following data on the control system in labeled three-ring binders with indexed tabs.
 1. Three copies of the controls training manuals.
 2. The O&M manual shall be organized and subdivided with permanently labeled tabs for each of the following data in the given order:
 - a. Sequences of operation
 - b. Control drawings
 - c. Points lists
 - d. Controller/module data
 - e. Thermostats and timers
 - f. Sensors and DP switches
 - g. Valves and valve actuators

- h. Dampers and damper actuators
 - i. Program setups (software program printouts)
3. Operation and Maintenance Manuals content:
- a. Specific instructions on how to perform and apply all functions, features, modes, etc., mentioned in the controls training sections of this specification and other features of this system. These instructions shall be step-by-step. Indexes and clear tables of contents shall be included. The detailed technical manual for programming and customizing control loops and algorithms shall be included.
 - b. Full as-built set of control drawings (refer to Submittal section above for details).
 - c. Full as-built sequence of operations for each piece of equipment.
 - d. Full points list.
 - e. Full print out of all schedules and set points after testing and acceptance of the system.
 - f. Full as-built print out of software program.
 - g. Electronic copy on disk of the entire program for this facility.
 - h. Marking of all system sensors and thermostats on the as-built floor plan and mechanical drawings with their control system designations.
 - i. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
 - j. Control equipment component submittals, parts lists, etc.
 - k. Warranty requirements.
 - l. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).
4. Field checkout sheets shall be provided to the Owner for inclusion in the Commissioning Record Book (merged with Systems Manual).
- C. Review and Approvals. Review of the commissioning related sections of the O&M manuals shall be made by the Owner. Refer to *Section 01 91 13*.

3.7 TRAINING OF OWNER PERSONNEL

- A. The [CM/GC] shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to *Section 01 91 13*.
- B. The Heating and Ventilating Contractors shall have the following additional training responsibilities:
 - 1. Provide the designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of mechanical equipment (pumps, airflow stations, air handling units, fans, cabinet heaters, and controls).
 - 2. Training shall normally start with discussion 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.
 - 3. 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.
 - 4. 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 and in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

5. The 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.
 6. 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.
 7. Training shall include:
 - a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
 - b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
 - c. Discussion of relevant health and safety issues and concerns.
 - d. Discussion of warranties and guarantees.
 - e. Common troubleshooting problems and solutions.
 - f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
 - g. Discussion of any peculiarities of equipment installation or operation.
 8. 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.
 9. The Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not *controlled* by the central building automation system.
 10. Training shall occur after functional testing is complete, unless approved otherwise by the Owner.
 11. Duration of Training. The contractor shall provide training on each piece of equipment according to *Section 23 05 00 [Note to AE: Include this section in the Contract Documents]*.
- C. The Heating Contractor shall have the following additional training responsibilities:
1. The Contractor shall provide the designated Owner personnel training on the building automation system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the building automation system.
 2. 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 Owner. Copies of audiovisuals shall be delivered to the Owner.
 3. The training will be tailored to the needs and skill-level of the trainees.
 4. The trainers will be knowledgeable on the system and its use in buildings. The Owner shall approve the instructor prior to scheduling the training.
 5. 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.
 6. Duration of Training. The Contractor shall provide training on each piece of equipment according to *Section 23 05 00 [Note to AE: Include this section in the Contract Documents]*.

3.8 DEFERRED TESTING

- A. Refer to Section 01 91 13 for requirements of deferred testing.

3.9 WRITTEN WORK PRODUCTS

- A. Written work products of Contractors will consist of the start-up and initial checkout plan, all other Plans, Contractor Tests, the filled out Start-up, all Checkouts such as but not limited to Pre-Functional Checklists, BAS and TAB (trend proofs, I/O value reports logs), Preliminary TAB and Final TAB Reports described herein and in *Section 01 91 13*.

END OF SECTION 23 08 00

This section of the *U of I Facilities Standards* establishes minimum requirements only.
It should not be used as a complete specification.