

SPECIAL SPECIFICATION

SECTION 15995S

MECHANICAL SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The purpose of this section is to specify Division 15 responsibilities in the commissioning process.
- B. The systems to be commissioned are listed in Section 01710S.
- C. Commissioning requires the participation of Division 15 and Division 13 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Division 1. Division 15 shall be familiar with all parts of Division 1 and the commissioning plan issued by the TE and shall execute all commissioning responsibilities assigned to them in the Contract Documents.
- D. Related Sections: 13995S, 01710S, 01715S, 16995S.

1.2 DEFINITIONS

- A. Refer to section 01715S

1.3 RESPONSIBILITIES

- A. Mechanical, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors of Division 15 are as follows (all references apply to commissioned equipment only):
 - 1. Construction and Acceptance Phases
 - a. Include and itemize the cost of commissioning in the contract price with a schedule of values.
 - b. In each purchase order or subcontract written, include requirements for submittal data, commissioning documentation, O&M data and training.
 - c. Attend a commissioning scoping meeting and other meetings necessary to facilitate the Cx process.
 - d. Contractors shall provide the TE with normal cut sheets and shop drawing submittals of commissioned equipment.
 - e. Provide additional requested documentation, prior to normal O&M manual submittals, to the TE for development of start-up and functional testing procedures.
 - 1) Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.
 - 2) The Commissioning Agent may request further documentation necessary for the commissioning process.
 - 3) This data request may be made prior to normal submittals.
 - f. Provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, to the TE for review and approval.
 - g. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control

drawings or equipment documentation is not sufficient for writing detailed testing procedures.

- h. Provide limited assistance to the TE in preparing the specific functional performance test procedures as specified in the draft Construction Phase Commissioning Plan. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
- i. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists from the TE for all commissioned equipment. Submit to TE for review and approval prior to startup. Refer to Section 01710S for further details on start-up plan preparation.
- j. During the startup and initial checkout process, execute the mechanical-related portions of the prefunctional checklists for all commissioned equipment.
- k. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the TE.
- l. Address current Construction Observer punch list items before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.
- m. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
- n. Perform functional performance testing under the direction of the TE for specified equipment in Construction Phase Commissioning Plan and 01710S. Assist the TE in interpreting the monitoring data, as necessary.
- o. Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, TE and A/E and retest the equipment.
- p. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
- q. Prepare red-line as-built drawings for all drawings and final as-builds for contractor-generated coordination drawings.
- r. Provide training of the Owner's operating personnel as specified.
- s. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

2. Warranty Period

- a. Execute seasonal or deferred functional performance testing, witnessed by the TE, according to the specifications.
- b. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

B. Mechanical Contractor. The responsibilities of the mechanical contractor, during construction and acceptance phases in addition to those listed in (A) are:

- 1. Provide startup for all HVAC equipment, except for the building automation control system.
- 2. Assist and cooperate with the TAB contractor and TE by:
 - a. Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
 - b. Including cost of sheaves and belts that may be required by TAB.
 - c. Providing test holes in ducts and plenums where directed by TAB to allow air measurements and air balancing. Providing an approved plug.
 - d. Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.
- 3. Install a P/T plug at each water sensor which is an input point to the control system.
- 4. List and clearly identify on the as-built drawings the locations of all air-flow stations.

5. Prepare a preliminary schedule for Division 15 pipe and duct system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the TE. Update the schedule as appropriate.
 6. Notify the GC or TE 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 GC or TE, 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 TE has the scheduling information needed to efficiently execute the commissioning process.
- C. Controls Contractor. The commissioning responsibilities of the controls contractor, during construction and acceptance phases in addition to those listed in (A) are:
1. Sequences of Operation Submittals. The Controls Contractor's 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:
 - a. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.
 - b. All interactions and interlocks with other systems.
 - c. 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.
 - d. Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included, but will generally require additional narrative).
 - e. Start-up sequences.
 - f. Warm-up mode sequences.
 - g. Normal operating mode sequences.
 - h. Unoccupied mode sequences.
 - i. Shutdown sequences.
 - j. Capacity control sequences and equipment staging.
 - k. Temperature and pressure control: setbacks, setups, resets, etc.
 - l. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
 - m. Effects of power or equipment failure with all standby component functions.
 - n. Sequences for all alarms and emergency shut downs.
 - o. Seasonal operational differences and recommendations.
 - p. Initial and recommended 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.
 - q. Schedules, if known.
 - r. 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.
 2. Control Drawings Submittal
 - a. The control drawings shall have a key to all abbreviations.
 - b. The control drawings shall contain graphic schematic depictions of the systems and each component.
 - c. 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.
 - d. Provide a full points list with at least the following included for each point:
 - 1) Controlled system
 - 2) Point abbreviation

- 3) Point description
 - 4) Display unit
 - 5) Control point or setpoint (Yes / No)
 - 6) Monitoring point (Yes / No)
 - 7) Intermediate point (Yes / No)
 - 8) Calculated point (Yes / No)
- e. Key:
 - f. Point Description: DB temp, airflow, etc.
 - g. Control or Setpoint: Point that controls equipment and can have its setpoint changed (OSA, SAT, etc.)
 - h. 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).
 - i. Monitoring Point: Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.
 - j. Calculated Point: "Virtual" point generated from calculations of other point values.
3. The Controls Contractor shall keep the TE informed of all changes to this list during programming and setup.
 4. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.
 5. Assist and cooperate with the TAB contractor in the following manner:
 - a. Meet with the TAB contractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control 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.).
 - b. For a given area, have all required prefunctional checklists, calibrations, startup and selected functional tests of the system completed and approved by the TE prior to TAB.
 - c. Provide a qualified technician to operate the controls to assist the TAB contractor in performing TAB, or provide sufficient training for TAB to operate the system without assistance.
 6. Assist and cooperate with the TE in the following manner:
 - a. Execute the functional testing of the controls system, mechanical equipment, electrical equipment and trend logs as specified in the Construction Phase Commissioning Plan and 01710S.
 7. The controls 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, according to the process in Section 01710S. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:
 - a. System name.
 - b. List of devices.
 - c. Step-by-step procedures for testing each controller after installation, including:
 - 1) Process of verifying proper hardware and wiring installation.
 - 2) Process of downloading programs to local controllers and verifying that they are addressed correctly.
 - 3) Process of performing operational checks of each controlled component.
 - 4) Plan and process for calibrating valve and damper actuators and all sensors.
 - 5) A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
 - d. A 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.

- e. A description of the instrumentation required for testing.
 - f. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the TE and TAB contractor for this determination.
8. Provide a signed and dated certification to the TE and GC upon completion of the checkout of each controlled device, equipment and system 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.
 9. Beyond the control points necessary to execute all documented control sequences, provide monitoring, control and virtual points as specified.
 10. 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).
- D. TAB Contractor. The duties of the TAB contractor, in addition to those listed in (A) are:
1. Six weeks prior to starting TAB, submit to the GC the qualifications of the site technician for the project, including the name of the contractors and facility managers of recent projects the technician on which was lead. The Owner will approve the site technician’s qualifications for this project.
 2. Submit the outline of the TAB plan and approach for each system and component to the TE, GC and the controls contractor six weeks prior to starting the TAB. This plan will be developed after the TAB has some familiarity with the control system.
 3. The submitted plan will include:
 - a. Certification that the TAB contractor has reviewed the construction documents and the systems with the design engineers and contractors to sufficiently understand the design intent for each system.
 - b. An explanation of the intended use of the building control system. The controls contractor will comment on feasibility of the plan.
 - c. All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
 - d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
 - e. Final test report forms to be used.
 - f. Detailed step-by-step procedures for TAB work for each system and issue: terminal flow calibration (for each terminal type), diffuser proportioning, branch / sub-main proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc. Criteria for using air flow straighteners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the water side.
 - g. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
 - h. Details of how *total* flow will be determined (Air: sum of terminal flows via BAS calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations. Water: pump curves, circuit setter, flow station, ultrasonic, etc.).
 - i. The identification and types of measurement instruments to be used and their most recent calibration date.
 - j. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and provide methods to verify this.
 - k. Confirmation that TAB understands the outside air ventilation criteria under all conditions.
 - l. Details of whether and how minimum outside air cfm will be verified and set and for what level (total building, zone, etc.).

- m. Details of how building static and exhaust fan / relief damper capacity will be checked.
 - n. Proposed selection points for sound measurements and sound measurement methods.
 - o. Details of methods for making any specified coil or other system plant capacity measurements.
 - p. Details of any TAB work to be done in phases (by floor, etc.), or of areas to be built out later.
 - q. Details regarding specified deferred or seasonal TAB work.
 - r. Details of any specified false loading of systems to complete TAB work.
 - s. Details of all exhaust fan balancing and capacity verifications, including any required room pressure differentials.
 - t. Details of any required interstitial cavity differential pressure measurements and calculations.
 - u. Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
 - v. Plan for formal progress reports (scope and frequency).
 - w. Plan for formal deficiency reports (scope, frequency and distribution).
4. A running log of events and issues shall be kept by the TAB field technicians. Submit hand-written reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the TE and GC at least twice a week.
 5. Communicate in writing to the controls contractor all setpoint and parameter changes made or problems and discrepancies identified during TAB which affect the control system setup and operation.
 6. Provide a draft TAB report within two weeks of completion. A copy will be provided to the TE. The report will contain a full explanation of the methodology, 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, NEBB or ASHRAE Standard 111.
 7. Provide the TE with any requested data, gathered, but not shown on the draft reports.
 8. Provide a final TAB report for the TE with details, as in the draft.
 9. Conduct functional performance tests and checks on the original TAB as specified for TAB in the Construction Phase Commissioning Plan and section 01710S.

1.4 RELATED WORK

- A. Refer to Section 01710S and 01715S for a listing of all sections where commissioning requirements are found, systems to be commissioned and functional testing requirements.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. Division 15 shall provide all test equipment necessary to fulfill the testing requirements of this Division.
- B. Refer to the Construction Phase Commissioning Plan and section 01710S for additional Division 15 requirements.

PART 3 - EXECUTION

3.1 SUBMITTALS

- A. Division 15 shall provide submittal documentation relative to commissioning as required in this Section and Section 01710S.

3.2 STARTUP

- A. The mechanical and controls contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in 01710S. Division 15 has start-up responsibility and is required 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 commissioning agent or Owner.
- B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the TE and GC. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.3 TAB

- A. Refer to the TAB responsibilities in Part 1.2 above.

3.4 FUNCTIONAL PERFORMANCE TESTS

- A. Refer to Section 01710S for a list of systems to be commissioned and a description of the process. Refer to the Construction Phase Commissioning Plan for specific details on the required functional performance tests.

3.5 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

- A. Refer to Section 01710S for specific details on non-conformance issues relating to prefunctional checklists and tests and issues relating to functional performance tests.

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.
 - 1. Division 15 shall compile and prepare documentation for all equipment and systems covered in Division 15 and deliver this documentation to the GC for inclusion in the O&M manuals, according to this section and Division 1, prior to the training of owner personnel.
 - 2. The TE shall receive a copy of the O&M manuals for review.
- B. Special Control System O&M Manual Requirements. In addition to documentation that may be specified elsewhere, the controls contractor shall compile and organize at minimum the following data on the control system in labeled 3-ring binders with indexed tabs.
 - 1. Three copies of the controls training manuals in a separate manual from the O&M manuals.
 - 2. Operation and Maintenance Manuals containing:
 - 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. In addition to the updated points list required in the original submittals (Part 1 of this section), a listing of all rooms shall be provided with the following information for each room:
 - 1) Floor
 - 2) Room number
 - 3) Room name
 - 4) Air handler unit ID
 - 5) Reference drawing number
 - 6) Air terminal unit tag ID

- 7) Heating and/or cooling valve tag ID
 - 8) Minimum cfm
 - 9) Maximum cfm
 - 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).
3. The 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)
4. Field checkout sheets and trend logs should be provided to the TE for inclusion in the Commissioning Record Book.
- C. Special TAB Documentation Requirements. The TAB will compile and submit the following with other documentation that may be specified elsewhere in the *Specifications*.
- 1. Final report containing an explanation of the methodology, assumptions, test conditions and the results in a clear format with designations of all uncommon abbreviations and column headings.
 - 2. The TAB shall mark on the drawings where all traverse and other critical measurements were taken and cross reference the location in the TAB report.
- D. Review and Approvals. Review of the commissioning related sections of the O&M manuals shall be made by the A/E and by the TE. Refer to Section 01710S, Part 3.8 for details.

3.7 TRAINING OF OWNER PERSONNEL

- A. The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01710S for additional details.
- B. The TE shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment. Refer to Section 01710S for additional details.
- C. Mechanical Contractor. The mechanical contractor shall have the following training responsibilities:
 - 1. Provide the TE with a training plan two weeks before the planned training according to the outline described in Section 01710S, Part 3.9.
 - 2. Provide designated Owner 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, pumps, boilers, furnaces, 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. 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.
 - h. The format and training agenda in *The HVAC Commissioning Process, ASHRAE Guideline 1-1989R*, 1996 is recommended.
 - i. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.
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 Project Manager.
12. Duration of Training. The mechanical contractor shall provide training on each piece of equipment according to the following schedule or as specified in the associated specification section, whichever is greater.

a.	<u>Hours</u>	<u>System</u>
b.	<u>40</u>	Chillers and System
c.	<u>8</u>	Cooling Towers
d.	<u>16</u>	Boilers and System
e.	<u>8</u>	Piping Systems
f.	<u>4</u>	Chemical Treatment
g.	<u>8</u>	Air Compressors/Clean Compressed Air System
h.	<u>8</u>	Air Handler Units
i.	<u>2</u>	Exhaust Fans
j.	<u>4</u>	Filter Fan Units

k.	4	Air Terminal Units (VAV & CV Boxes)
l.	4	Packaged Rooftop Units
m.	4	Computer Room AC Units (CRAC)
n.	4	Split System AC or Heat Pumps
o.	40	Direct Digital Controls
p.	16	Acid, Solvent, Ammonia Exhaust Systems
q.	40	Fume Scrubbers
r.	40	Acid Waste Neutralization System
s.	8	Hydrofluric Acid Waste System
t.	8	Reclaim Water Systems
u.	8	Recycle Water Systems
v.	40	RO/DI Water Systems
w.	8	PH Adjust Chemical Metering System
x.	8	Process Chilled Water Systems
y.	8	Ultra High Purity Gas Distribution Systems
z.	8	Process Vacuum System
aa.	8	Breathing Air System
bb.	16	Fire Protection System / Automatic Sprinklers

D. Controls Contractor. The controls contractor shall have the following training responsibilities:

1. Provide the TE with a training plan four weeks before the planned training according to the outline described in Section 01710S.
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.

E. 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 TE. Copies of audiovisuals shall be delivered to the Owner.

1. The trainings will be tailored to the needs and skill-level of the trainees.
2. 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.
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 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.
5. There shall be three training sessions:
 - a. Training I. Control System. The first training shall consist of 40 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 40 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 setpoints 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.

c. Training III. The third training will be conducted on-site six months after occupancy and consist of 16 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.

F. TAB The TAB contractor shall have the following training responsibilities:

1. TAB shall meet for 8 hours 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.

3.8 DEFERRED TESTING

A. Refer to Section 01710S, 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 described in Section 01710S and the filled out start-up, initial checkout and prefunctional checklists.

END OF SECTION