

**SECTION 230800  
COMMISSIONING OF HVAC**

**PART 1 GENERAL****1.01 DESCRIPTION**

- A. The purpose of this section is to specify Division 23 responsibilities in the commissioning process. Each Contractor mentioned in this section is responsible for the costs of supporting the commissioning requirements of this and other Division 23 sections.
- B. The systems to be commissioned are listed in a subsequent Article: SCOPE.
- C. Commissioning requires the participation of Division 23 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed elsewhere in this Section. Division 23 shall be familiar with all parts of this Section and the commissioning plan issued by the Commissioning Authority and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

**1.02 ROLES AND 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:
  - 1. Construction and acceptance phases
    - a. Include and itemize the cost of contractor commissioning responsibilities in the contract price 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 commissioning process.
    - d. Contractors shall provide the Commissioning Authority through the CM with normal cut sheets and shop drawing submittals of commissioned equipment.
    - e. Provide additional requested documentation, prior to preparation of O&M manual submittals, to the Commissioning Authority for development of start-up and functional testing procedures.
    - f. 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 Authority.
    - g. The Commissioning Authority may request further documentation necessary for the commissioning process.
    - h. This data request may be made prior to normal submittals.
    - i. Provide a copy of the O&M manuals and shop of equipment to be commissioned, through normal channels, to the Commissioning Authority for review and approval.
    - j. Contractors shall assist (along with the Engineer of Record) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for conducting detailed testing procedures.
    - k. Provide limited assistance to the Commissioning Authority in preparing the specific functional performance test procedures. Contractors shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
    - l. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the pre-startup checklists for all commissioned equipment. Submit to Commissioning Authority for review and approval prior to startup. Refer to other parts of this Section for further details on start-up plan preparation.

- m. During the startup and initial checkout process, execute the mechanical-related portions of the pre-startup checklists for all commissioned equipment.
  - n. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the Commissioning Authority.
  - o. Resolve current A/E punch list items before functional verification testing. TAB shall be completed with discrepancies and problems remedied before functional verification testing of the required systems.
  - p. Provide skilled technicians to execute starting of equipment and to assist the Commissioning Authority with execution the functional verification 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.
  - q. Correct deficiencies (differences between specified and observed performance) as interpreted by the Commissioning Authority, CM and Engineer of Record and retest the equipment with the Commissioning Authority present.
  - r. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
  - s. During construction, maintain as-built red-line drawings of all applicable drawings and contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing).
  - t. Provide training of the Owner's operating staff using expert qualified personnel, as specified.
  - u. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
2. Warranty period
- a. Assist the Commissioning Authority with execution of seasonal or deferred functional verification testing.
  - b. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified during seasonal testing.
- B. Mechanical Contractor: The responsibilities of the HVAC 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 Commissioning Authority 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. 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 23 pipe and (duct – if specified elsewhere) system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the Commissioning Authority. Update the schedule as appropriate.
  - 6. Notify the CM or Commissioning Authority depending on protocol, when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Notify the CM or Commissioning Authority in advance of scheduling problem(s) caused by commissioning activities not yet performed or not yet scheduled. Be proactive in seeing that commissioning processes are executed and that the Commissioning Authority has the scheduling information needed to efficiently execute the commissioning process.
  - 7. Training
    - a. Provide the Commissioning Authority with a training plan two weeks before the planned training.
    - b. 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.

- c. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, that shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
  - d. 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.
  - e. 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 are required. More than one party may be required to execute the training.
  - f. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manuals in order to illustrate the use of the O&M manuals for reference.
  - g. Training shall include:
  - h. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
  - i. 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.
  - j. Discussion of relevant health and safety issues and concerns.
  - k. Discussion of warranties and guarantees.
  - l. Common troubleshooting problems and solutions.
  - m. Explanatory information included in the O&M manuals.
  - n. Discussion of any peculiarities of equipment installation or operation.
  - o. The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1-1989R, 1996 is recommended.
  - p. Classroom sessions shall include the use of computerized projections.
  - q. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance.
  - r. The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central automation system.
  - s. Training shall occur whenever the equipment is fully operational.
- 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, set points 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. 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 also numbered.
2. Control Drawings Submittal: The Controls Contractor shall keep the Commissioning Authority informed of all changes to this list during programming and setup.
- 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 set point
    - 6) Monitoring point
    - 7) Intermediate point
    - 8) Calculated point
    - 9) Key:
      - (a) Point Description: DB temp, airflow, etc.
      - (b) Control or Set point: Point that controls equipment and can have its set point changed (OSA, SAT, etc.)
      - (c) 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).
      - (d) Monitoring Point: Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.
      - (e) Calculated Point: "Virtual" point generated from calculations of other point values.
3. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.
4. 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 pre-startup checklists, calibrations and startup of the system completed and approved by the Commissioning Authority 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 the TAB technician to operate the system without assistance.
5. Assist and cooperate with the Commissioning Authority in the following manner:
  - a. Using the Lead Installation Technician (LIT), execute the functional verification testing of the controls system as specified for the controls contractor and required by the Commissioning Authority prior to the functional verification testing of all HVAC equipment. Provide two-way radios during the testing.
  - b. Provide control system trend log capabilities as specified elsewhere in this Section.
6. 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 their final sign-off . 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 point-to-point 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 Commissioning Authority and TAB contractor for this determination.
7. Provide a signed and dated certification to the Commissioning Authority and CM 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.
8. Beyond the control points necessary to execute all documented control sequences, provide monitoring, control and virtual points as specified in Section 230900.
9. 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).
10. Training:
  - a. Provide the Commissioning Authority with a training plan four weeks before the planned training.
  - b. 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.
  - c. 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 Commissioning Authority. Copies of audiovisuals shall be delivered to the Owner.
  - d. The trainings will be tailored to the needs and skill-level of the trainees.

- e. 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.
  - f. 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.
  - g. 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.
  - h. There shall be three training sessions:
    - 1) Training I. Control System: The first training shall consist of 6 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.
    - 2) Training II. Building Systems: The second session shall be held on-site for a period of 4 hours of actual hands-on training after the completion of system commissioning. The session shall include instruction on:
      - (a) 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.
      - (b) 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.
      - (c) 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.
      - (d) Every screen shall be completely discussed, allowing time for questions.
      - (e) Use of keypad or plug-in laptop computer at the zone level.
      - (f) Use of remote access to the system via phone lines or networks.
      - (g) Setting up and changing an air terminal unit controller.
      - (h) Graphics generation.
      - (i) Point database entry and modifications
    - 3) Training III: The third training will be conducted on-site six months after occupancy and consist of 4 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 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 CM 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 Commissioning Authority, CM 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 / submain 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 Commissioning Authority and CM at least twice a week.
  5. Communicate in writing to the controls contractor all set point 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 Commissioning Authority. 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 Commissioning Authority with any requested data, gathered, but not shown on the draft reports.
  8. Provide a final TAB report for the Commissioning Authority with details, as in the draft.
  9. Conduct functional verification tests and checks on the original TAB as specified for TAB in Section 230593.
  10. Training:
    - a. TAB shall meet for 2 hours with facility staff after completion of TAB and instruct them on the following:
      - 1) Go over the final TAB report, explaining the layout and meanings of each data type.
      - 2) Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
      - 3) Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
      - 4) Discuss any temporary settings and steps to finalize them for any areas that are not finished.
      - 5) Other salient information that may be useful for facility operations, relative to TAB.
- E. Mechanical Engineer of Record. Refer to Articles throughout this Section for miscellaneous responsibilities.

### 1.03 EXCLUSIONS

- A. Responsibility for construction means and methods: the commissioning agent is not responsible for construction means, methods, job safety, or any construction management functions on the job site.
- B. Hands-on work by the Commissioning Agent: The contractors shall provide all services requiring tools or the use of tools to start-up, test, adjust, or otherwise bring equipment and systems into a fully operational state. The Commissioning Authority shall coordinate and observe these procedures (and may make minor adjustments), but shall not perform construction or technician services other than verification of testing, adjusting, balancing, and control functions.

### 1.04 SCOPE

- A. The following equipment, assemblies and systems are subject to the commissioning process (refer to drawings for impacted systems):
  1. Automatic Temperature Controls, Upgraded, Retrofit and New.
  2. Air Handling Units.
  3. Exhaust Systems
  4. Central Hot Water Plants
  5. Central Chilled Water Plants
  6. Packaged Rooftop Systems
  7. Hot Water, Chilled Water & Air Distribution Systems and Related Equipment
  8. Domestic Water Heaters and Pumps
  9. Systems Testing and Balancing Verification

### 1.05 DOCUMENTATION

- A. The Commissioning Authority shall oversee and maintain the development and acquisition of commissioning documentation. The commissioning documentation shall be kept in three ring binders, and organized by document categories. A table of contents page(s) shall be updated as the process goes along so as to facilitate finding certain documents. The commissioning documentation shall include, but not be limited to, the following. Most of this documentation will

- be inserted into the final Commissioning Report:
- B. A spreadsheet shall be set up by the Commissioning Authority midway through the HVAC installation/construction period to initially track all "punch list" items discovered during construction. Eventually it will become the tracking document for all commissioning issues until final completion and closeout of the project.
  - C. Approved test and balance report for the building being commissioned furnished by the TAB Contractor.
  - D. All accepted shop drawings of mechanical equipment. Fold shop drawings larger than 8.5 x 11" sheets as required to fit in binders furnished by the Mechanical Contractor.
  - E. All blank pre-start-up equipment testing checklists, organized by system and sub-system furnished by the Mechanical Contractor to include at least the following as appropriate:
    - 1. Vibration and seismic controls for HVAC&R piping and equipment.
    - 2. Instrumentation and control for HVAC&R.
    - 3. Heating-water piping and accessories.
    - 4. Cooling-water piping and accessories.
    - 5. Steam and condensate piping and accessories.
    - 6. Refrigerant piping.
    - 7. Metal ducts and accessories.
    - 8. Fans.
    - 9. Particulate air filtration.
    - 10. Air-handling units.
    - 11. Computer-room air conditioners.
    - 12. Boilers.
    - 13. Chillers.
    - 14. Pumps.
    - 15. HVAC piping flushing reports and test results
  - F. All equipment functional test checklists/results, signed by manufacturers or contractor technician, organized by system and sub-system furnished by the Mechanical Contractor.
  - G. Three copies of the operation and maintenance (O & M) manuals specified in other sections of these specifications shall be included with the commissioning documentation for review by the Commissioning Authority as well as the Engineer of Record; furnished by the Mechanical Contractor.
  - H. Letter of certification verifying that the facility's heating, ventilation and air conditioning system has been installed and operates according to design specifications provided by the Commissioning Authority.

#### **1.06 COORDINATION**

- A. The Commissioning Authority shall receive a copy of all construction documents, addenda, change orders, and appropriate approved submittals and shop drawings directly from the design professionals or Construction Manager through the course of construction.
- B. The Commissioning Authority shall disseminate written information and documents to all responsible parties relative to the nature and extent of the communication.
- C. The Commissioning Authority is primarily responsible to the Owner, and as such, shall regularly apprise the Construction Manager and the Owner of progress, pending problems and/or disputes, and shall provide regular status reports on progress with each system. Any potential change in the contractual and financial obligations of the owner (credits, change orders, schedule changes, etc.) shall be identified and quantified as soon as possible.
- D. The Commissioning Authority shall coordinate the schedule of commissioning activities with the construction schedule. It is possible that some Commissioning activities such as system and equipment training will be completed before complete HVAC system functionality is achieved.

#### **1.07 SCHEDULE**

- A. Contractor schedules and scheduling is the responsibility of the Construction Manager.

- B. The Commissioning Authority shall provide commissioning scheduling information to the Construction Manager for review and planning activities.
- C. Certain major activities must be completed in succession w/o any overlap – WITHOUT EXCEPTION:
- D. Controls hardware/wiring installation, controllers programming, head end configuration/ completed/functional systems graphics, Controls Contractor internal commissioning/complete checkout and signoff of the CONTROLS READINESS STATEMENT issued to the Commissioning Authority.
- E. Testing Adjusting and Balancing work.
- F. Preparation of the TAB report.
- G. Review of the TAB report and final sign-off by the Commissioning Authority & Engineer of Record.
- H. Functional Verification Testing by the Commissioning Authority.
- I. Preparation of the Final Commissioning Report.

#### **1.08 RELATED WORK SPECIFIED ELSEWHERE**

- A. Commissioning requires support from the contractors as specified in this and related sections.
- B. The commissioning process does not relieve any contractors from their obligations to complete all portions of work in a satisfactory manner.
- C. Related sections include 001300 – Submittals, 230593 - Testing Adjusting & Balancing for HVAC, 230900 - Controls and Instrumentation.

### **PART 2 PRODUCTS**

#### **2.01 TEST EQUIPMENT**

- A. The appropriate Contractors shall furnish all special tools and equipment required during the commissioning process. A list of all tools and equipment with relevant calibration to be used during commissioning shall be submitted to the Commissioning Agent for approval. The owner shall furnish necessary utilities for the commissioning process.

#### **2.02 PROPRIETARY TEST EQUIPMENT**

- A. 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.

### **PART 3 EXECUTION**

#### **3.01 GENERAL**

- A. A commissioning process kick-off meeting of all commissioning team members shall be held at a time and place designated by the construction manager. The purpose shall be to familiarize all parties with the commissioning process, and to ensure that the responsibilities of each party are clearly understood.
- B. The Commissioning Authority shall develop and submit a Commissioning Plan document for presentation at the kick-off meeting. Included shall be the required work by all team members (Commissioning Agent, design team, contractors, and the Owner). The Contractor shall complete all phases of work so the systems can be started, tested, balanced, and acceptance procedures undertaken. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, etc., per the contract documents and related directives, clarifications, and change orders.
- C. Acceptance procedures are normally intended to begin prior to completion of a system and/or sub-systems, and shall be coordinated with the Mechanical Contractor. Start of acceptance procedures before system completion does not relieve the contractor from completing those systems as per the schedule and must happen prior to the bulk of the Commissioning process.

**3.02 STARTUP**

- A. The HVAC mechanical and controls contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities elsewhere in this Section. Division 23 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 Authority or Owner.
- B. Functional verification testing is intended to begin upon completion of a system in the order or activities listed above. Beginning system testing does not relieve the Contractor from fully completing the system, including all pre-start-up checklists as soon as possible

**3.03 CONTRACTOR PARTICIPATION IN ACCEPTANCE PROCEDURES**

- A. The Contractor shall provide skilled technicians to startup and debug all systems within Division 23. These same technicians shall be made available to assist the Commissioning Authority in completing the commissioning program. Work schedules, time required for testing, etc., shall be requested by the Commissioning Agent and coordinated by the Contractors. Contractor shall ensure that the qualified technicians are available and present during the agreed upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.
- B. System performance problems and discrepancies may require additional technician time, commissioning agent time, reconstruction of systems, and/or replacement of system components. The additional technician time shall be made available for subsequent commissioning periods until the required system performance is obtained.
- C. The Commissioning Authority reserves the right to question the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians shall include expert knowledge relative to the specific equipment involved and a willingness to work with the Commissioning Authority. Contractor shall provide adequate documentation and tools to start-up and test the equipment, system, and/or sub-system.
- D. The Controls Contractor shall comply with and return a signed CONTROLS READINESS STATEMENT to the Commissioning Agent prior to start of functional testing. A sample copy is included here (following page):

**3.04 TAB VERIFICATION**

- A. Prerequisites: Completion of "Examination" Article requirements and correction of deficiencies, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
- B. Completion of "Preparation" Article requirements for preparation of a TAB plan that includes strategies and step-by-step procedures, and system-readiness checks and reports, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
- C. Commissioning Test Demonstration Sampling Rate: As specified in "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
- D. Under all conditions, rechecked measurements comply with "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
- E. No rechecked measurement shall differ from measurements documented in the final report by more than two times the tolerances allowed.
- F. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

**3.05 DEFICIENCY RESOLUTION**

- A. In some systems, maladjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work shall be completed under the direction of the Construction Manager, with input from the Contractor, Equipment Supplier, and Commissioning Authority. Whereas all members shall have input and the opportunity to discuss, debate, and work out problems, the Owner and/or

Engineer of Record shall have final authority over any additional work done to achieve performance.

- B. Corrective work shall be completed in a timely fashion to permit the completion of the commissioning process. Experimentation to demonstrate system performance may be permitted. If the Commissioning Authority deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the Commissioning Authority shall notify the Construction Manager and Owner, indicating the nature of the problem, expected steps to be taken, and suggested deadline(s) for completion of activities. If the deadlines pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner shall be the Contractor's responsibility.
- C. Corrective work additional commissioning usually occurs after and sometimes well after the issue of the certificate of Substantial Completion. But by no means will a Certificate of Final Completion be issued and release of all retainage until the Commissioning Authority gives consent to the Construction Manager and Owner as is stated in the Supplementary Conditions to the Contract contained in the Project Manual/Contract documents.

### **3.06 ADDITIONAL COMMISSIONING**

- A. Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The Contractors, Suppliers, and Commissioning Authority shall include a reasonable reserve to complete this work as part of their contractual obligations.

**END OF SECTION 230800**