

## **PART 1– GENERAL**

### **1.1 Applicable Standards**

- .1 2015 ASHRAE Handbook – HVAC Applications Chapter 43 HVAC Commissioning
- .2 ASHRAE Guideline 1.1 – 2007 – The HVAC&R Technical Requirements for the Commissioning Process
- .3 CSA Z320-11 (R2016) Building Commissioning Standard & Check Sheets

### **1.2 Description**

- .1 Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the Region’s operational needs. The commissioning process begins in the design phase and continues through construction, acceptance and the warranty period. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing and balancing, functional testing and training.
- .2 Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:
  - .1 Verify that applicable equipment and systems are installed according to the manufacturer’s recommendations and industry best practices, and that they receive adequate operational checkout by installing Subcontractors;
  - .2 Verify and document proper performance of equipment and systems;
  - .3 Verify that Operations and Maintenance documentation left on Site is complete; and
  - .4 Verify that the Region’s operating personnel are adequately trained.
- .3 The commissioning process does not take away from or reduce the responsibility of the system designers or installing Subcontractors to provide a finished and fully functioning product.

### **1.3 Abbreviations**

- .1 The following are common abbreviations used in the Commissioning Specifications and in the Commissioning Plan. Definitions are found in Section 1.8.

A/E-	Architect and Design Engineers (the “Consultant”)	FT-	Functional performance test
CA-	Commissioning Authority	GC-	General Contractor (the ‘Contractor”)
CC	Controls Subcontractor	MC-	Mechanical Subcontractor
PM-	Project Manager (of the GC)	PC-	Pre-functional checklists
Cx-	Commissioning	Subs-	Subcontractors to GC
Cx Plan-	Commissioning Plan document	TAB-	Test and Balance Subcontractor
EC-	Electrical Subcontractor	FM	Facility Management

#### **1.4 COORDINATION**

- .1 Commissioning Team. The commissioning team consists of the representatives from the Region, the Facility Management (FM) Staff, Commissioning Authority (CA), the Project Manager (PM), the General Contractor (GC or Contractor), the Architect and Design Engineers (A/E) (the "Consultant"), the mechanical Subcontractor (MC), the electrical Subcontractor (EC), the Testing and Balancing (TAB) Subcontractor, the controls Subcontractor (CC), any other installing subcontractors or suppliers of equipment.
- .2 Management. The CA is hired by the Region and follows the rules of an Independent Commissioning Authority. The CA directs and coordinates the commissioning activities and reports to the Region. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents.
- .3 Scheduling. The CA will work with the PM and GC according to established protocols to schedule the commissioning activities. The CA will provide sufficient notice to the PM and GC for scheduling commissioning activities. The GC shall integrate all commissioning activities into the master schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process. The CA will work with the GC to provide the initial schedule of primary commissioning events at the commissioning scoping meeting. The Commissioning Plan provides a format for this schedule. As construction progresses more detailed schedules are developed by the GC and the CA. The Commissioning Plan also provides a format for detailed schedules.

#### **1.5 COMMISSIONING PROCESS**

- .1 Commissioning Plan. The commissioning plan provides guidance in the execution of the commissioning process. Following the commissioning scoping meeting, the CA will update the plan which is then considered the "final" plan, though it will continue to evolve and expand as the project progresses. The Specifications will take precedence over the Commissioning Plan.
- .2 Commissioning Process. The following narrative provides a brief overview of the typical commissioning tasks during construction and the general order in which they occur.
  - .1 Commissioning during construction begins with a scoping meeting conducted by the CA where the commissioning process is reviewed with the commissioning team members.
  - .2 Additional meetings will be required throughout construction, scheduled by the CA with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.
  - .3 Equipment documentation is submitted to the CA during normal submittals, including detailed start-up procedures and Shop Drawings.
  - .4 The CA works with the Subs in developing startup plans and startup documentation formats, including providing the Subs with pre-functional test sheets to be completed during the startup process.
  - .5 In general, the checkout and performance verification proceeds from simple to complex; from component level, to equipment, to systems, and finally intersystem levels with pre-functional test sheets being completed before functional testing.

- .6 The Subs, under their own direction, execute and document the pre-functional test sheets and perform startup and initial checkout. The CA documents that the test sheets and startup were completed according to the approved plans. This may include the CA witnessing start-up of selected equipment.
- .7 The CA develops specific equipment and system functional performance test procedures with the assistance of Subs as required. The Subs review the test procedures once prepared.
- .8 The procedures are executed by the Subs, under the direction of, and documented by the CA.
- .9 Items of non-compliance in material, installation or setup are corrected at the Sub's expense and the system retested.
- .10 The CA reviews the O&M documentation for completeness.
- .11 Commissioning is completed before Substantial Performance of the Contract.
- .12 Deferred testing is conducted, as specified or required.

## 1.6 RELATED WORK

- .1 Specific commissioning requirements are given in the following Sections of these Specifications. All of the following sections apply to the Work of this Section.

01 91 00	Commissioning	<i>Describes the commissioning process, responsibilities common to all parties, responsibilities of the Consultant, CA, GC and Suppliers, focusing on the CA. The unique MC, CC, TAB and EC (including the Subcontractors for the Special Systems) responsibilities are included in Divisions 21, 22, 23, 25, 26, and 28.</i>
21 10 00 22 08 00 23 08 00 25 08 00	Fire Suppression System Cx Plumbing Cx HVAC Cx Integrated Automation Cx	<i>Describes the Cx responsibilities of the Fire Protection, Plumbing, Mechanical, TAB and Controls Contractors and the pre-functional testing and startup responsibilities of each. Points to 01 91 00 for functional testing requirements and provides the pre-functional and the specific functional testing requirements for Division 21, 22, 23 and 25 equipment, for use on this project.</i>
26 08 00	Electrical Cx	<i>Describes the specific Cx responsibilities of the Division 26 Subcontractor.</i>

## 1.7 RESPONSIBILITIES

- .1 General: General Commissioning Responsibilities are as follows:

- .1 The responsibilities of various parties in the commissioning process are provided in this Section. The responsibilities of the mechanical Subcontractor and TAB are in Division 23 and controls Subcontractor are in Division 25; those of the electrical Subcontractor in Division 26, and Electronic Safety and Security in Division 28. It is noted that the services for the Project Manager, the Consultant including HVAC, Mechanical, and Electrical Designers/Engineers, are not provided for in this Section. That is, the Contractor is not responsible for providing services covered under these parties scope; their responsibilities are listed here to clarify the commissioning process.
- .2 All Parties: Commissioning responsibilities for all parties are as follows:
  - .1 Attend commissioning scoping meeting and additional meetings, as necessary.
- .3 Architect (of the Consultant): Commissioning responsibilities of the Architect are as follows:
  - .1 Attend the commissioning scoping meeting and selected commissioning team meetings.
  - .2 Perform normal submittal review, construction observation, As-Built Drawing preparation, O&M manual preparation, etc., as contracted.
  - .3 Provide any design narrative documentation requested by the CA.
  - .4 Coordinate resolution of system deficiencies identified during commissioning, according to the Contract Documents.
  - .5 Prepare and submit final as-built design intent documentation for inclusion in the O&M manuals. Review the O&M manuals.
  - .6 Coordinate resolution of design non-conformance and design deficiencies identified during warranty-period commissioning.
- .4 Mechanical and Electrical Designers/Engineers (of the Consultant): Commissioning responsibilities of the Mechanical and Electrical Engineers are as follows:
  - .1 Perform normal submittal review, construction observation, As-Built Drawing preparation, etc., as contracted. One Site observation should be completed just prior to system startup.
  - .2 Provide any design narrative and sequences documentation requested by the CA. The Designers shall assist (along with the GC and/or Subcontractors) 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.
  - .3 Attend commissioning scoping meetings and other selected commissioning team meetings.
  - .4 Participate in the resolution of system deficiencies identified during commissioning, according to the Contract Documents.
  - .5 Prepare and submit the final as-built design intent and operating parameters documentation for inclusion in the O&M manuals. Review the O&M manuals.

- .6 From the Contractor's red-line drawings, edit and update one-line diagrams developed as part of the design narrative documentation and those provided by the vendor as Shop Drawings for the chilled and hot water, condenser water, domestic water, steam and condensate systems; supply, return and exhaust air systems and emergency power system.
- .7 Provide a presentation at one of the training sessions for the Region's personnel.
- .8 Witness testing of selected pieces of equipment and systems.
- .9 Participate in the resolution of non-compliance, non-conformance and design deficiencies identified during commissioning during warranty-period commissioning.
- .5 Commissioning Authority (CA): Commissioning Responsibilities of the Commissioning Authority are as follows:
  - .1 The CA is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CA may assist with problem-solving non-conformance or deficiencies, but ultimately that responsibility resides with the General Contractor and the Consultant. The primary role of the CA is to develop and coordinate the execution of a testing plan, observe and document performance that systems are functioning in accordance with the documented design intent and in accordance with the Contract Documents. The GC and/or Subcontractors will provide all tools or the use of tools to start, check-out and functionally test equipment and systems, except for specified testing with portable data-loggers, which shall be supplied and installed by the CA.
  - .2 Coordinates and directs the commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules and technical expertise.
  - .3 Coordinate the commissioning work and, with the GC ensure that commissioning activities are being scheduled into the master schedule.
  - .4 Develop and issue the Commissioning Plan.
  - .5 Plan and conduct a commissioning scoping meeting and other commissioning meetings.
  - .6 Before startup, review the current control sequences and interlocks and work with the GC and Subcontractors and Design Engineers until sufficient clarity has been obtained, in writing, to be able to write detailed functional testing procedures.
  - .7 Review submittals provided by the GC and Subcontractors applicable to systems being commissioned for compliance with commissioning needs, concurrent with the Consultant reviews. Request and review additional information required to perform commissioning tasks, including O&M materials, contractor start-up and checkout procedures.
  - .8 Write and distribute pre-functional tests and test sheets.
  - .9 Develop an enhanced start-up and initial systems checkout plan with Subs.

- .10 Perform Site visits, as necessary, to observe component and system installations. Attend selected planning and Site meetings to obtain information on construction progress. Review construction meeting minutes for revisions/substitutions relating to the commissioning process. Assist in resolving any discrepancies.
- .11 Witness all or part of the HVAC piping test and flushing procedure, sufficient to be confident that proper procedures were followed. Notify the Region and the PM of any deficiencies in results or procedures.
- .12 Witness all or part of any ductwork testing and cleaning procedures, sufficient to be confident that proper procedures were followed. Notify the Region and the PM of any deficiencies in results or procedures.
- .13 Approve pre-functional tests and checklist completion by reviewing pre-functional checklist reports and by selected Site observation and spot checking.
- .14 Approve systems start-up by reviewing start-up reports and by selected Site observation.
- .15 Review TAB execution plan.
- .16 Oversee sufficient functional testing of the control system and approve it to be used for TAB, before TAB is executed.
- .17 Review air and water systems balancing by spot testing, by reviewing completed reports, and by selected Site observation.
- .18 With necessary assistance and review from installing Subcontractors, write the functional performance test procedures for equipment and systems. This may include energy management control system trending, stand-alone data-logger monitoring, or manual functional testing.
- .19 Analyze any functional performance trend logs and monitoring data to verify performance.
- .20 Coordinate, witness and approve manual functional performance tests performed by installing Subcontractors. Coordinate retesting as necessary until satisfactory performance is achieved. Perform actual functional testing with contractors on equipment so specified in Section 01 91 00 sub-section 1.9.
- .21 Maintain a master deficiency and resolution log and a separate testing record. Provide the Region with written progress reports and test results with recommended actions.
- .22 Witness performance testing of smoke control systems by others and all other Region contracted tests or tests by manufacturer's personnel over which the CA may not have direct control. Document these tests and include this documentation in Commissioning Binders.
- .23 Review equipment warranties to ensure that the Region's responsibilities are clearly defined.
- .24 Oversee and approve the training of the Region's operating personnel. Compile and maintain a commissioning record book(s).
- .25 Review the preparation of the O&M manuals. Provide a final commissioning report (as described in this Section).
- .26 Develop a Systems Operating Manual.

- .27 Coordinate and supervise required seasonal or deferred testing and deficiency corrections.
- .28 Return to the Site at 20 months into the 24 month warranty period and review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal commissioning. Also interview facility staff and identify problems or concerns they have operating the building as originally intended. Make suggestions for improvements and for recording these changes in the O&M manuals. Identify areas that may come under warranty or under the original construction contract. Assist facility staff in developing reports, documents and requests for services to remedy outstanding problems.
- .6 Contractor/Project Manager (PM): Commissioning Responsibilities of the Contractor/Project Manager are as follows:
  - .1 Facilitate the coordination of the commissioning work by the CA, and ensure that commissioning activities are being scheduled into the master schedule.
  - .2 Review the final Commissioning Plan.
  - .3 Attend a commissioning scoping meeting and other commissioning team meetings.
  - .4 Include the cost of commissioning in the total contract price.
  - .5 Perform the normal review of the Contractor's submittals.
  - .6 Furnish a copy of all construction documents, addenda, change orders and approved submittals and shop drawings related to commissioned equipment to the CA.
  - .7 In each purchase order or subcontract written, include requirements for submittal data, O&M data, commissioning tasks and training.
  - .8 Ensure that all Subs execute their commissioning responsibilities according to the Contract Documents and schedule.
  - .9 Observe and witness pre-functional test sheets, startup and functional testing.
  - .10 Review commissioning progress and deficiency reports.
  - .11 Coordinate the resolution of non-compliance and design deficiencies identified in all phases of commissioning.
  - .12 Sign-off on individual commissioning tests as completed and passing.
  - .13 Coordinate the training of Region personnel.
  - .14 Arrange for facility operating and maintenance personnel to attend various field commissioning activities and field training sessions according to the Final Commissioning Program.
  - .15 Assist the CA as necessary in the seasonal or deferred testing and deficiency corrections required by the specifications.
  - .16 Ensure that Subs execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.
  - .17 Ensure that Subs correct deficiencies and make necessary adjustments to O&M manuals and As-Built Drawings for applicable issues identified in any seasonal testing.

- .7 Equipment Suppliers: Commissioning Responsibilities of the Equipment Suppliers are as follows:
- .1 Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Region to keep warranties in force.
  - .2 Assist in equipment testing per agreements with Subs, which may include factory tests and the development of associated reports.
  - .3 All costs associated with provision of all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents shall be included in the Contract Price, except for stand-alone data-logging equipment that may be used by the CA.
  - .4 Through the contractors they supply products to, analyze specified products and verify that the designer has specified the newest most updated equipment reasonable for this project's scope and budget.
  - .5 Provide information requested by CA regarding equipment sequence of operation and testing procedures.
  - .6 Review test procedures for equipment installed by factory representatives.

## **1.8 DEFINITIONS**

The following definitions apply to this Section in addition to the defined term included in the Definitions Section of the Contract:

- .1 Approval - acceptance that a piece of equipment or system has been properly installed and is functioning in the tested modes according to the Contract Documents.
- .2 Commissioning Authority (CA) – The CA works independent of the design and constructions teams. The CA directs and coordinates the day-to-day commissioning activities. The CA does not take an oversight role like the PM. The CA is part of the Project Manager (PM) team or shall report directly to the PM.
- .3 Commissioning Plan - an overall plan that provides the structure, schedule and coordination planning for the commissioning process.
- .4 Control system - the central building energy management control system.
- .5 Data-logging - monitoring flows, currents, status, pressures, etc. of equipment using stand-alone data-loggers separate from the control system.
- .6 Deferred Functional Tests – FT's that are performed later, after achieving Substantial Performance of the Contract, due to partial occupancy, equipment, seasonal requirements, design or other Site conditions that disallow the test from being performed.
- .7 Deficiency - a condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents (that is, does not perform properly or is not compliant with the design intent).
- .8 Factory Testing - testing of equipment on Site or at the factory by factory personnel with a Region representative present.



- .9 Functional Test (FT) - test of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Functional testing is the dynamic testing of systems (rather than just components) under full operation (e.g., the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. Traditional air or water test and balancing (TAB) is not functional testing, in the commissioning sense of the word. TAB Subcontractor's primary work is setting up the system flows and pressures as specified, while functional testing is verifying that which has already been set up. The commissioning authority develops the functional test procedures in a sequential written form, coordinates, oversees and documents the actual testing, which is usually performed by the installing Subcontractor or vendor. FTs are performed after pre-functional test sheets and startup are complete.
- .10 Manual Test - using hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the "observation").
- .11 Monitoring - the recording of parameters (flow, current, status, pressure, etc.) of equipment operation using data-loggers or the trending capabilities of control systems.
- .12 Non-Compliance - see Deficiency.
- .13 Non-Conformance - see Deficiency.
- .14 Over-written Value - writing over a sensor value in the control system to see the response of a system (e.g., changing the outside air temperature value from 50F to 75F to verify economizer operation). See also "Simulated Signal."
- .15 Region-Contracted Tests - tests paid for by the Region outside the GC's Contract and for which the CA does not oversee. These tests will not be repeated during functional tests if properly documented.
- .16 Phased Commissioning - commissioning that is completed in phases (by floors, for example) due to the size of the structure or other scheduling issues, in order minimize the total construction time.
- .17 Pre-functional Checklist (PC) - a list of items to inspect and elementary component tests to conduct to verify proper installation of equipment, provided by the CA to the Sub. Pre-functional test sheets are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels satisfactory, labels affixed, gages in place, sensors calibrated, etc.). However, some pre-functional checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase pump motor of a chiller system). Pre-functional refers to before functional testing and shall be completed by the installing Subcontractor. Pre-functional test sheets augment and are combined with the manufacturer's start-up checklist. The CA may choose to witness pre-functional tests for large/critical pieces of equipment.
- .18 Project Manager (PM) - the General Contractor's representative in the day-to-day activities of construction.
- .19 Sampling - functionally testing only a fraction of the total number of identical or near identical pieces of equipment. Refer to Section 01 91 00, Part 3.5.9.8 for details.

- .20 Seasonal Performance Tests - FT's that are deferred until the system(s) will experience conditions closer to their design conditions.
- .21 Simulated Condition - condition that is created for the purpose of testing the response of a system (e.g., applying a hair blower to a space sensor to see the response in a VAV box).
- .22 Simulated Signal - disconnecting a sensor and using a signal generator to send an amperage, resistance or pressure to the transducer and Direct Digital Control (DDC) system to simulate a sensor value.
- .23 Startup - the initial starting or activating of dynamic equipment, including executing pre-functional test sheets.
- .24 Test Procedures - the step-by-step process which must be executed to fulfill the test requirements. The test procedures are developed by the CA.
- .25 Test Requirements - requirements specifying what modes and functions, etc. shall be tested. The test requirements are not the detailed test procedures. The test requirements are specified in the Contract Documents (Sections 25 08 00 and 26 08 00)
- .26 Trending - monitoring using the building control system.
- .27 Vendor - supplier of equipment.
- .28 Warranty Period - warranty period for entire project as set out in Article A-15 \_ Warranty Period in the Agreement Between Owner and Contractor as amended, including equipment components.

## **1.9 SYSTEMS TO BE COMMISSIONED**

- .1 Systems to be commissioned have been detailed below:
  - .1 Building Automation System – For Equipment/Systems in scope of work only
  - .2 Energy Recovery Ventilator
  - .3 Ground Source Pre-Heater
  - .4 Heat Pumps
  - .5 Condensing Units
  - .6 Exhaust Fans
  - .7 Gas Fired Infrared Heaters
  - .8 Destratification Fans
  - .9 Cartridge Type Humidifier
  - .10 Split AC Units
  - .11 Unit Heaters
  - .12 Baseboard Heaters
  - .13 Force Flow Heaters
  - .14 Switchgear, Distribution Panel, and Panelboards
  - .15 Generator
  - .16 Lighting and Lighting Controls

## **PART 2- PRODUCTS**

### **2.1 Test Equipment**

- .1 The Contractor shall ensure that all standard testing equipment required to perform startup and initial checkout and required functional performance testing be provided by the GC or Division Subcontractor for the equipment being tested. For example, the HVAC Subcontractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC system and controls systems except for equipment specific to and used by TAB in their commissioning responsibilities.
- .2 All costs associated with the special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the Contract Price, except for stand-alone datalogging equipment that may be used by the CA.
- .3 Data-logging equipment and software required to test equipment will be provided by the CA, but shall not become the property of the Region.
- .4 All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. Temperature sensors and digital thermometers shall have a certified calibration within the past year to accuracy of 0.28°C (0.5°F) and a resolution of  $\pm 0.056^{\circ}\text{C}$  (0.1°F). Pressure sensors shall have an accuracy of  $\pm 2.0\%$  of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

## **PART 3- EXECUTION**

### **3.1 Meetings**

- .1 The CA will schedule, plan and conduct a commissioning scoping meeting with the entire commissioning team in attendance. Meeting minutes will be distributed to all parties by the CA. Information gathered from this meeting will allow the CA to create the Commissioning Plan to its "final" version, which will also be distributed to all parties.
- .2 Miscellaneous Meetings. Other meetings will be planned and conducted by the CA as construction progresses. These meetings will cover coordination, deficiency resolution and planning issues with particular Subs. The CA will plan these meetings and will minimize unnecessary time being spent by Subs.

### **3.2 Reporting**

- .1 The CA will provide regular reports to the PM and the Region, depending on the management structure, with increasing frequency as construction and commissioning progresses. Standard forms are provided and referenced in the Commissioning Plan.
- .2 The CA will regularly communicate with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling changes through memos, progress reports, etc.
- .3 Testing or review approvals and non-conformance and deficiency reports are made regularly with the review and testing as described in later sections.

- .4 A final summary report developed by the CA will be provided to the PM and the Region, focusing on evaluating commissioning process issues and identifying areas where the process could be improved. Pre-functional test sheets and functional tests will not be part of the final report, but will be stored in the Commissioning Binders.

### **3.3 Submittals**

- .1 The Contractor and its Subcontractors shall provide the CA standard submittals required to facilitate the commissioning work. This process will be integrated into the normal submittal process and protocol of the construction team. At a minimum, the submittals will include equipment shop drawings, the manufacturer's printed installation and detailed start-up procedures, full sequences of operation, O&M data, performance data, any performance test procedures, control drawings, and details of Region contracted tests. In addition, the installation and checkout materials that are shipped inside the equipment and the field checkout forms to be used by the factory or field technicians shall be submitted to the Commissioning Authority. The Contractor shall ensure that all documentation requested by the CA is included by the Subs in their O&M manual contributions.
- .2 The Commissioning Authority will review submittals related to the commissioned equipment for conformance Region's project requirements as they relate to the commissioning process.
- .3 The CA may request additional design narrative from the Consultant and controls Subcontractor, depending on the completeness of the design intent documentation and sequences provided with the Specifications.
- .4 These submittals to the CA do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the Contractor, though the CA will review them.

### **3.4 Start-up, Pre-Functional Test Sheets and Initial Checkout**

- .1 The following procedures apply to all equipment to be commissioned. Some systems that are not comprised so much of actual dynamic machinery (e.g. electrical system power quality) may have very simplified PCs and startup.
  - .1 General. Pre-functional test sheets are a critical commissioning piece in order to ensure functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full pre-functional checkout. No sampling strategies are used. The pre-functional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.
  - .2 Start-up and Initial Checkout Plan. The CA shall assist the commissioning team members responsible for startup of any equipment in developing detailed start-up plans for all equipment. The primary role of the CA in this process is to ensure that there is written documentation that each of the manufacturer recommended procedures have been completed. Parties responsible for pre-functional test sheets and startup are identified in the commissioning scoping meeting and in the checklist forms. The parties responsible for executing functioning performance testing are detailed in specific commissioning specification sections (refer to Section 01 91 00 subsection 1.6 of this document for details).

- .3 Pre-functional test scripts are provided by the CA to the Contractor. The Contractor determines which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form. Each form will have more than one trade responsible for its execution.
- .4 The Contractor shall ensure that the Subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining (or adding to) the CA's test sheets with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include test sheets and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan. The full start-up plan could consist of something as simple as:
  - .1 The CA's pre-functional test sheets.
  - .2 The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.
  - .3 The manufacturer's normally used field checkout sheets.
- .5 The Contractor submits the full startup plan to the CA for review.
- .6 The CA reviews the procedures and the format for documenting them, noting any procedures that need to be added.
- .7 The full start-up procedures and the approval form may be provided to the PM for review depending on management protocol.
- .2 Sensor and Actuator Calibration:
  - .1 All field-installed temperature, relative humidity, CO/CO2, and pressure sensors/gauges, and all actuators (dampers and valves) on all equipment shall be calibrated using the methods described below. Alternate methods may be used, if accepted by the Region in advance. All test instruments shall have had a certified calibration within the last 12 months. Sensors installed in the unit at the factory with calibration certification provided need not be field calibrated.
  - .2 All procedures used shall be fully documented on the pre-functional test sheets or other suitable forms, clearly referencing the procedures followed and written documentation of initial, intermediate and final results.
- .3 Sensor Calibration Methods:
  - .1 All Sensors Verify that all sensor locations are appropriate and away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading, of each other, for pressure.
  - .2 Sensors Without Transmitters--Standard Application. Make a reading with a calibrated test instrument within 6 inches of the Site sensor. Verify that the sensor reading (via the permanent thermostat, gage or Building Automation System (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, install offset in BAS, calibrate or replace sensor.

- .3 Sensors With Transmitters--Standard Application. Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the BAS. Record all values and recalibrate controller as necessary to conform with specified control ramps, reset schedules, proportional relationship, reset relationship and Proportional/Integral reaction. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the Site sensor. Verify that the sensor reading (via the permanent thermostat, gage or BAS) is within the tolerances in the table below of the instrument-measured value. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.

.4 Tolerances, Standard Applications

Sensor	Required Tolerance [+/-]	Sensor	Required Tolerance (+/-)
Cooling coil, chilled and condenser water temps	0.22°C (0.4°F)	Flow rates, water	4% of design
AHU wet bulb or dew point	1.11°C (2.0°F)	Relative humidity	4% of design
Hot water coil and boiler water temp	0.83°C (1.5°F)	Combustion flue temps	2.78°C (5.0°F)
Outside air, space air, duct air temps	0.22°C (0.4°F)	Oxygen or CO <sub>2</sub> monitor	0.1 % pts
Watt hour, voltage & amperage	1% of design	CO monitor	0.01 % pts
Pressures, air, water and gas	3% of design	Natural gas and oil flow rate	1% of design
Flow rates, air	10% of design	Steam flow rate	3% of design
		Barometric pressure	338.639 Pa (0.1 in. of Hg)

.5 Valve and Damper Stroke Setup and Check:

- .1 EMS Readout For all valve and damper actuator positions checked, verify the actual position against the BAS readout. Set pumps or fans to normal operating mode. Command valve or damper closed, visually verify that valve or damper is closed and adjust output zero signal as required. Command valve or damper open, verify position is full open and adjust output signal as required. Command valve or damper to a few intermediate positions. If actual valve or damper position doesn't reasonably correspond, replace actuator or add pilot positioner (for pneumatics).
- .2 Closure for heating coil valves (NO): Set heating setpoint 11.11°C (20°F) above room temperature. Observe valve open. Remove control air or power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. Set heating setpoint to 11.11°C (20°F) below room temperature. Observe the valve close. Restore to normal.

- .3 Closure for cooling coil valves (NC): Set cooling setpoint 11.11°C (20°F) above room temperature. Observe the valve close. Remove control air or power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. Set cooling setpoint to 11.11°C (20°F) below room temperature. Observe valve open. Restore to normal.
- .6 Execution of Pre-functional Test Sheets and Startup:
  - .1 The Contractor shall ensure that, 28 days prior to startup, the Subs and vendors schedule startup and checkout with the Contractor and CA. The performance of the pre-functional test sheets, startup and checkout are directed and executed by the Sub or vendor. When checking off pre-functional test sheets, signatures may be required of other Subs for verification of completion of their work.
  - .2 The CA shall observe, at minimum, the procedures for each piece of primary equipment, unless there are multiple units, (in which case a sampling strategy may be used as accepted by the PM).
  - .3 For lower-level components of equipment, (e.g., VAV boxes, sensors, controllers), the CA shall observe a sampling of the pre-functional and start-up procedures.
  - .4 The Contractor shall ensure that the Subs and vendors execute startup and provide the CA with a signed and dated copy of the completed start-up and pre-functional tests and test sheets.
  - .5 Only individuals that have direct knowledge and witnessed that a line item task on the pre-functional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.
- .7 Deficiencies, Non-Conformance and Approval in Test Sheets and Startup:
  - .1 The Contractor shall ensure that the Subs clearly list any outstanding items of the initial start-up and pre-functional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies are provided to the CA within two days of test completion.
  - .2 The CA reviews the report and submits either a non-compliance report or an approval form to the Region. The CA shall work with the Subs and vendors to correct and retest deficiencies or uncompleted items. The CA will involve the PM and others as necessary. The Contractor shall ensure that the installing Subs or vendors correct all areas that are deficient or incomplete in the test sheets and tests in a timely manner, and shall notify the CA as soon as outstanding items have been corrected and resubmit an updated start-up report and a Statement of Correction on the original non-compliance report. When satisfactorily completed, the CA recommends approval of the execution of the test sheets and startup of each system to the PM using a standard form.

### **3.5 Functional Testing**

- .1 This sub-section applies to all commissioning functional testing for all divisions.
- .2 Systems to be Commissioned: The list of equipment to be commissioned is detailed in specific commissioning specification sections (refer to Section 01 91 00 subsection 1.6 of this document for details).

- .3 Objectives and Scope: The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.
- .4 In general, each system should be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, low oil pressure, no flow, equipment failure, etc. shall also be tested.
- .5 Development of Test Procedures: Before test procedures are written, the CA shall obtain all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. Using the testing parameters and requirements in specific commissioning specification sections (refer to Section 01 91 00 subsection 1.6 of this document for details), the CA shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. The Contractor shall ensure that each Sub or vendor responsible to execute a test provides limited assistance to the CA in developing the procedures review (answering questions about equipment, operation, sequences, etc.). Prior to execution, the CA shall provide a copy of the test procedures to the Sub(s) who shall review the tests for feasibility, safety, equipment and warranty protection. The CA may submit the tests to the Consultant for review, if requested.
- .6 The CA shall review Region-contracted, factory testing or required Region acceptance tests which the CA is not responsible to oversee, including documentation format, and shall determine what further testing or format changes may be required to comply with the Specifications. Redundancy of testing shall be minimized.
- .7 The purpose of any given specific test is to verify and document compliance with the stated criteria of acceptance given on the test form.
- .8 The test procedure forms developed by the CA shall include (but not be limited to) the following information:
  - .1 System and equipment or component name(s)
  - .2 Equipment location and ID number
  - .3 Date
  - .4 Project name
  - .5 Participating parties
  - .6 A copy of the specification section describing the test requirements
  - .7 A copy of the specific sequence of operations or other specified parameters being verified
  - .8 Required pre-test field measurements (filled-up pre-functional tests)
  - .9 Instructions for setting up the test.
  - .10 Specific step-by-step procedures to execute the test, in a clear, sequential and repeatable format



- .11 Acceptance criteria of proper performance with a Yes / No check box to allow for clearly marking whether or not proper performance of each part of the test was achieved.
- .12 A section for comments
- .13 Signatures and date block for the CA and all participating parties.
- .9 Test Methods:
  - .1 Test Execution Functional performance testing and verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone data-loggers. The CA may substitute specified methods or require an additional method to be executed, other than what was specified, with the approval of the Region. This may require a change order and adjustment in charge to the Region. The CA will determine which method is most appropriate for tests that do not have a method specified.
  - .2 Simulated Conditions Simulating conditions (not by an overwritten value) shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.
  - .3 Overwritten Values: Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be something other than it really is, shall be allowed, but shall be used with caution and avoided when possible. Such testing methods often can only test a part of a system, as the interactions and responses of other systems will be erroneous or not applicable. Simulating a condition is preferable. e.g., for the above case, by heating the outside air sensor with a hair blower rather than overwriting the value or by altering the appropriate setpoint to see the desired response. Before simulating conditions or overwriting values, sensors, transducers and devices shall have been calibrated.
  - .4 Simulated Signals: Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended over using the sensor to act as the signal generator via simulated conditions or overwritten values.
  - .5 Altering Setpoints: Rather than overwriting sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable. For example, to see the AC compressor lockout work at an outside air temperature below 55°F, when the outside air temperature is above 55°F, temporarily change the lockout setpoint to be 2°F above the current outside air temperature.
  - .6 Indirect Indicators: Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the tested parameters, that the indirect readings through the control system represent actual conditions and responses. Much of this verification is completed during pre-functional testing.

- .7 Setup: Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The Contractor shall ensure that the Sub executing the test provides all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At completion of the test, the Sub shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.
- .8 Sampling: Multiple identical pieces of non-life-safety or otherwise non-critical equipment may be functionally tested using a sampling strategy. Significant application differences and significant sequence of operation differences in otherwise identical equipment invalidates their common identity. A small size or capacity difference, alone, does not constitute a difference. It is noted that no sampling by Subs is allowed in pre-functional checklist execution.  
  
A common sampling strategy referenced in the Specifications as the “xx% Sampling—yy% Failure Rule” is defined by the following example.  
  
xx = the percent of the group of identical equipment to be included in each sample.  
  
yy = the percent of the sample that if failing, will require another sample to be tested.  
  
The example below describes a 20% Sampling—10% Failure Rule.
- .9 Randomly test at least 20% (xx) of each group of identical equipment. In no case test less than three units in each group. This 20%, or three, constitute the “first sample.”
- .10 If 10% (yy) of the units in the first sample fail the functional performance tests, test another 20% of the group (the second sample).
- .11 If 10% of the units in the second sample fail, test all remaining units in the whole group.
- .12 If at any point, frequent failures are occurring and testing is becoming more troubleshooting than verification, the CA may stop the testing and require the responsible Sub to perform and document a checkout of the remaining units, prior to continuing with functionally testing the remaining units.
- .10 Coordination and Scheduling:
  - .1 The Subs shall provide sufficient notice to the CA regarding their completion schedule for the pre-functional test sheets and startup of all equipment and systems. The CA will schedule functional tests through the Contractor and affected Subs. The CA shall direct, witness and document the functional testing of all equipment and systems. The Contractor shall ensure that the Subs execute the tests.
  - .2 In general, functional testing is conducted after pre-functional testing and startup has been satisfactorily completed. The control system is sufficiently tested and approved by the CA before it is used for TAB or to verify performance of other components or systems. The air balancing and water balancing is completed and debugged before functional testing of air-related or water-related equipment or systems. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

- .11 Test Equipment.: Refer to Section 01 91 00, Part 2 for test equipment requirements.
- .12 Problem Solving: The CA will recommend solutions to problems found, however it is the responsibility of the Subs, and the GC to solve, correct and retest problems.

### **3.6 Documentation, Non-Conformance and Approval of Tests**

- .1 Documentation: The CA shall witness and document the results of all functional performance tests using the specific procedural forms developed for that purpose. Prior to testing, these forms are provided to the PM for review and to the Subs for review. The CA will include the filled out forms in the Commissioning Binders.
- .2 Non-Conformance:
  - .1 All deficiencies or non-conformance issues shall be noted and reported to the PM on a standard non-compliance form.
  - .2 Corrections of minor deficiencies identified may be made during the tests at the discretion of the CA. In such cases the deficiency and resolution will be documented on the procedure form.
  - .3 Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CA will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues.
  - .4 As tests progress and a deficiency is identified, the CA discusses the issue with the executing contractor.
    - .1 When there is no dispute on the deficiency and the Sub accepts responsibility to correct, the following course of action occurs:
      - .2 The CA documents the deficiency in deficiency tracking log and issues to the Project Team. The Sub corrects the issue and signs off on the deficiency tracking log indicating the issue has been resolved.
      - .3 The CA reschedules the test and the test is repeated. If the test is successful, the CA closes the item.
  - .5 If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:
    - .1 The deficiency shall be documented on the deficiency tracking log with the Sub's response and a copy given to the PM and to the Sub representative assumed to be responsible.
    - .2 Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the Consultant. Final acceptance authority is with the Region.
    - .3 The CA documents the resolution process.
    - .4 Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs off on the deficiency tracking log and provides it to the CA. The CA reschedules the test and the test is repeated until satisfactory performance is achieved, at which time the CA closes the item.
- .6 Cost of Retesting:

- .1 The cost for the Sub to retest a pre-functional or functional test, if they are responsible for the deficiency, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the GC.
- .2 For a deficiency identified, not related to any pre-functional checklist or start-up fault, the following shall apply: The CA and PM will direct the retesting of the equipment once at no "charge" to the GC for their time. However, the CA's time for a second retest will be charged to the GC.
- .3 The time for the CA and PM to direct any retesting required because a specific pre-functional checklist or start-up test item, reported to have been successfully completed, but determined during functional testing to be faulty, will be backcharged to the GC.
- .4 Refer to the sampling section of Section 01 91 00, Part 3.5 for requirements for testing and retesting identical equipment.
- .7 The Contractor shall respond in writing to the CA and PM at least as often as commissioning meetings are being scheduled concerning the status of each apparent outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.
- .8 The CA retains the original deficiency tracking log until the end of the project.
- .9 Any required retesting by any contractor shall not be considered a justified reason for a claim of delay or for a time extension by the Contractor.
- .3 Approval:
  - .1 The CA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CA and by the Region, if necessary. The CA recommends acceptance of each test to the Region using a standard form. The Region gives final approval on each test using the same form, providing a signed copy to the CA and the Contractor.

### **3.7 Operation and Maintenance Manuals**

- .1 The specific content and format requirements for the standard O&M manuals are detailed in Mechanical and Electrical Specifications.
- .2 Consultant Contribution: The Consultant will include in the beginning of the O&M manuals a separate section describing the systems including:
  - .1 The design intent narrative prepared by the Consultant and provided as part of the Contract Documents, updated to as-built status by the Consultant.
  - .2 Simplified professionally drawn single line system diagrams on 215.9mm x 279.4mm (8 ½" x 11") or 279.4mm x 431.8mm (11" x 17") sheets. These shall include chilled water system water system, heating system, steam system, supply air systems, exhaust systems, domestic hot water and electrical single lines. These shall show major pieces of equipment.

- .3 CA Review Prior to Substantial Performance of the Contract, the CA shall review the O&M manuals, documentation and redline as-builts for systems that were commissioned and to verify compliance with the Specifications. The CA will communicate deficiencies in the manuals to the Region or Consultant, as requested. Upon a successful review of the corrections, the CA recommends acceptance of these sections of the O&M manuals to the Region or Consultant. The CA also reviews each equipment warranty and verifies that all requirements to keep the warranty valid are clearly stated. This work does not supersede the Consultant's review of the O&M manuals.

### **3.8 Training of Region Personnel**

- .1 The GC shall be responsible for training coordination and scheduling, and ultimately for ensuring that training is completed.
- .2 The CA shall interview the facility manager and lead engineer to determine the special needs and areas where training will be most valuable. The Region and CA shall decide how rigorous the training should be for each piece of commissioned equipment. The CA shall communicate the results to the Subs and vendors who have training responsibilities.
- .3 In addition to these general requirements, the detailed training requirements of the Region personnel by Subs and vendors is detailed in specific commissioning specification sections (refer to Section 01 91 00 Subsection 1.6 of this document for details).
- .4 Each Sub and vendor responsible for training will submit a written training plan to the CA for review and approval prior to training. The plan will cover the following elements:
  - .1 Equipment (included in training)
  - .2 Intended audience
  - .3 Location of training
  - .4 Objectives
  - .5 Subjects covered (description, duration of discussion, special methods, etc.)
  - .6 Duration of training on each subject
  - .7 Instructor for each subject
  - .8 Methods (classroom lecture, video, Site walk-through, actual operational demonstrations, written handouts, etc.)
  - .9 Instructor and qualifications
- .5 For the primary HVAC equipment, the controls Subcontractor shall provide a short discussion of the control of the equipment during the mechanical or electrical training conducted by others.
- .6 The CA develops an overall training plan and coordinates and schedules, with the Region, the overall training for the commissioned systems. The CA develops criteria for determining that the training was satisfactorily completed, including attending some of the training, etc. The CA recommends approval of the training to the Region using a standard form. The Region will also sign the approval form.

- .7 The Mechanical and Electrical Design Engineer shall at the first training session present the overall system design concept and the design concept of each equipment section. This presentation shall include a review of all systems using the simplified system schematics (one-line drawings) including chilled water systems, heating systems, air distribution system, control system strategies, electrical distribution, fire systems, etc.

### 3.9 Deferred Testing

- .1 Unforeseen Deferred Tests If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of test sheets and functional testing may be delayed upon approval of the Region. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Services of necessary parties will be negotiated.
- .2 Seasonal Testing During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) shall be completed as part of this contract. The CA shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the appropriate Subs, with facilities staff and the CA witnessing. Any final adjustments to the O&M manuals and as-builts due to the testing will be made.

### 3.10 WRITTEN WORK PRODUCTS

- .1 The commissioning process generates a number of written work products described in various parts of the Specifications. The Commissioning Plan lists all the formal written work products, describes briefly their contents, who is responsible to create them, their due dates, who receives and approves them and the location of the specification to create them. In summary, the written products are:

<u>Product</u>	<u>Developed By</u>
1. Final commissioning plan	CA
2. Commissioning Meeting Minutes	CA
3. Commissioning Schedule	CA with GC and PM
4. Equipment documentation submittals	Subs
5. Sequence clarifications	Subs and A/E as needed
6. Pre-functional test sheets	CA
7. Startup and initial checkout plan	Subs and CA (compilation of existing documents)
8. Startup and initial checkout forms filled out	Subs
9. Final TAB report	TAB Subcontractor
10. Issues log (deficiencies)	CA
11. Commissioning Progress Record	CA
12. Functional test forms	CA
13. Filled out functional tests	CA
14. O&M manuals	Subs
15. Final Commissioning Documentation	CA
16. Overall training plan	CA and PM
17. Specific training agendas	Subs
18. Final commissioning report	CA
19. Misc. approvals	CA

**END OF SECTION**

## **PART 1 – GENERAL**

### **1.1 General**

- .1 The purpose of this section is to specify Division 21 responsibilities in the commissioning process.
- .2 The systems to be commissioned are listed in Section 01 91 00, Part 1.9.
- .3 Commissioning requires the participation of Division 21 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 21 shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.
- .4 CA = Commissioning Agent, TAB = Test and Balance Subcontractor.

### **1.2 Responsibilities**

- .1 Fire Suppression Subcontractor: The Contractor shall ensure that the fire suppression Subcontractor(s) complies with all requirements included in this Section and fulfills the following responsibilities during construction and acceptance phases (all references apply to commissioned equipment only):
  - .1 Documentation of all procedures performed shall be provided and forwarded to the Professional Engineer of Record. Written documentation must contain recorded test values of all tests performed per the individual product specification.
  - .2 The start-up service company shall be present during energization of the plumbing equipment. Site and equipment access must be provided by the fire suppression Subcontractor.
  - .3 The Contractor shall supply a power source, specified by the start-up service company, for on-Site test equipment.
  - .4 The fire suppression Subcontractor is to attend all factory witness testing required within the respective Specification Sections. All costs associated with the work of this Section shall be included in the Contract Price.
  - .5 Perform tests using qualified personnel. Provide necessary instruments and equipment.
  - .6 Include the cost of commissioning in the Contract Price, if not yet included.
  - .7 In each purchase order or subcontract written, include requirements for submittal data, O&M data and training.
  - .8 Attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the commissioning process.
  - .9 The Contractor and its Subcontractors shall provide normal cut sheets and shop drawing submittals to the CA of commissioned equipment. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of pre-functional and functional testing procedures.

- .1 Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any Region-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Region to keep the warranty in force clearly identified. In addition, the installation 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. This data request may be made prior to normal submittals.
- .10 Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CA for review.
- .11 The Contractor and its Subcontractors shall assist (along with the design Professional 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.
- .12 Provide assistance to the CA in preparation of the specific functional performance test procedures specified in Section 21. Subcontractors shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
- .13 Develop a full start-up and checkout plan using manufacturer's start-up procedures and the pre-functional test sheets from the CA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures and other requested equipment documentation to CA for review.
- .14 During the startup and checkout process, execute and document the mechanical-related portions of the pre-functional test sheets provided by the CA for all commissioned equipment.
- .15 Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.
- .16 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.
- .17 Perform functional performance testing under the direction of the CA for specified equipment in 01 91 00, Subsection 1.9. Assist the CA in interpreting the monitoring data, as necessary.
- .18 Correct deficiencies (differences between specified and observed performance) as interpreted by the CA and Consultant and retest the equipment.
- .19 Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.



- .20 During construction, maintain as-built red-line drawings for all drawings and final CAD as-builts for Contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing). Prepare red-line As-Built Drawings for all drawings and final as-builts for Contractor-generated coordination drawings.
- .21 Provide training of the Region's operating personnel as specified in Section 3.5 below.
- .22 Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
- .23 Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the Specifications.
- .24 Correct deficiencies and make necessary adjustments to O&M manuals and As-Built Drawings for applicable issues identified in any seasonal testing.
- .25 Assist and cooperate with the Mechanical and TAB Subcontractor and CA by:
  - .1 Putting all equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
  - .2 List and clearly identify on the As-Built Drawings the locations of equipment.
  - .3 Prepare a preliminary schedule for Division 21 equipment start-up, as well as TAB start and completion for use by the CA. Update the schedule as appropriate.
  - .4 Notify the Consultant and CA when pipe testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the Consultant and CA, 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 CA has the scheduling information needed to efficiently execute the commissioning process.

## **PART 2- PRODUCTS**

- .1 NOT USED

## **PART 3- EXECUTION**

### **3.1 Submittals**

- .1 The Contractor shall ensure that Section 21 Subcontractors provide submittal documentation relative to commissioning to the CA as requested by the CA. Refer to Section 01 91 00 Part 3.3 for additional Section 21 requirements.

### **3.2 Start-up of Equipment**

- .1 The fire suppression Subcontractor(s) shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in 01 91 00. Division 21 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 the Region.

- .2 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 CA and Consultant. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre functional checklists as soon as possible.
- .3 Prior to the start up of equipment the Division 21 Subcontractor shall arrange to have the manufacturer of all major equipment inspect the installation to ensure their equipment has been installed in accordance with their recommendations.
- .4 The supplier shall submit a written report of their findings.
- .5 Upon confirmation that the equipment has been installed in accordance with the manufacturer's recommendations the equipment may be started.
- .6 All equipment shall be started by the manufacturer's representative.

### **3.3 Pre-Functional Test Sheets**

- .1 Pre-functional test sheets contain items for Section 21 Subcontractors to perform. On each checklist, a column is provided that is to be completed by the Contractor assigning responsibility for that line item to a Subcontractor. Those executing the test sheets are only responsible to perform items that apply to the specific application at hand. These test sheets do not take the place of the manufacturer's recommended checkout and start-up procedures or report. Some checklist procedures may be redundant in relation to checkout procedures that will be documented on typical factory field checkout sheets. Double documenting may be required in those cases.
- .2 Refer to Section 01 91 00 for additional requirements regarding pre-functional test sheets, startup and initial checkout.

### **3.4 Operations and Maintenance Manuals**

- .1 The Contractor shall ensure that the Section 21 Subcontractors compile and prepare documentation for all equipment and systems covered in Section 21 and deliver it to the Contractor for inclusion in the O&M manuals.
- .2 The CA shall receive a copy of the O&M manuals for review.

### **3.5 Training of Region Personnel**

- .1 The Contractor shall coordinate and schedule training and ultimately to ensure that training is completed. Refer to Section 01 91 00 for additional details.
- .2 The CA will oversee and approve the content and adequacy of the training of the Region personnel for commissioned equipment. Refer to Section 01 91 00 for additional details.
- .3 Fire Suppression Subcontractor. The Contractor shall ensure that the fire suppression Subcontractor fulfills the following training responsibilities:
  - .1 Provide the CA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00, Part 3.8.
  - .2 Provide the designated the Region personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of commissioned fire suppression equipment

- .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 Subcontractor 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 Subcontractor 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 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:
  - .1 Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
  - .2 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.
  - .3 Discussion of relevant health and safety issues and concerns.
  - .4 Discussion of warranties and guarantees.
  - .5 Common troubleshooting problems and solutions.
  - .6 Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
  - .7 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 fire suppression Subcontractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
- .10 Training shall occur after functional testing is complete, unless approved otherwise by the the Region's PM.

### **3.6 Deferred Testing**

- .1 Refer to Section 01 91 00, Part 3.9 for requirements of deferred testing.

**3.7 WRITTEN WORK PRODUCTS**

- .1 Written work products of Section 21 Subcontractors will consist of the startup and initial checkout plan as described in Section 01 91 00, as well as completed startup, initial checkout and pre-functional test sheets.

**END OF SECTION**

## **PART 1 – GENERAL**

### **1.1 General**

- .1 The purpose of this section is to specify Division 22 responsibilities in the commissioning process.
- .2 The systems to be commissioned are listed in Section 01 91 00, Part 1.9.
- .3 Commissioning requires the participation of Division 22 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 22 shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.
- .4 CA = Commissioning Agent, TAB = Test and Balance.

### **1.2 Responsibilities**

- .1 Plumbing Subcontractor: The Contractor shall ensure that the plumbing Subcontractor complies with all requirements included in this Section and fulfills the following responsibilities during construction and acceptance phases (all references apply to commissioned equipment only):
  - .1 Documentation of all procedures performed shall be provided and forwarded to the Professional Engineer of Record. Written documentation must contain recorded test values of all tests performed per the individual product specification.
  - .2 The start-up service company shall be present during energization of the plumbing equipment. Site and equipment access must be provided by the plumbing Subcontractor.
  - .3 The Contractor shall supply a power source, specified by the start-up service company, for on-Site test equipment.
  - .4 The plumbing Subcontractor is to attend all factory witness testing required within the respective specification sections. The Contractor shall cover all their costs and include them in their bid.
  - .5 Perform tests using qualified personnel. Provide necessary instruments and equipment.
  - .6 Include the cost of commissioning in the Contract Price, if not yet included.
  - .7 In each purchase order or subcontract written, include requirements for submittal data, O&M data and training.
  - .8 Attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the commissioning process.
  - .9 The Contractor shall provide normal cut sheets and shop drawing submittals to the CA of commissioned equipment. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of pre-functional and functional testing procedures.

- .1 Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any Region-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Region to keep the warranty in force clearly identified. In addition, the installation 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. This data request may be made prior to normal submittals.
- .10 Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CA for review.
- .11 The Contractor shall assist (along with the design Professional 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.
- .12 Provide assistance to the CA in preparation of the specific functional performance test procedures specified in Section 22. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
- .13 Develop a full start-up and checkout plan using manufacturer's start-up procedures and the pre-functional test sheets from the CA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures and other requested equipment documentation to CA for review.
- .14 During the startup and checkout process, execute and document the mechanical-related portions of the pre-functional test sheets provided by the CA for all commissioned equipment.
- .15 Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.
- .16 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.
- .17 Perform functional performance testing under the direction of the CA for specified equipment in 01 91 00, Section 1.9. Assist the CA in interpreting the monitoring data, as necessary.
- .18 Correct deficiencies (differences between specified and observed performance) as interpreted by the CA and Consultant and retest the equipment.
- .19 Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

- .20 During construction, maintain as-built red-line drawings for all drawings and final CAD as-builts for Contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing). Prepare red-line As-Built Drawings for all drawings and final as-builts for Contractor-generated coordination drawings.
- .21 Provide training of the Region's operating personnel as specified.
- .22 Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
- .23 Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the Specifications.
- .24 Correct deficiencies and make necessary adjustments to O&M manuals and As-Built Drawings for applicable issues identified in any seasonal testing.
- .25 Assist and cooperate with the Mechanical and TAB Subcontractor and CA by:
  - .1 Putting all equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
  - .2 Providing temperature and pressure taps according to the Contract Documents for TAB and commissioning testing.
- .26 Install a P/T plug at each water sensor which is an input point to the control system.
- .27 List and clearly identify on the As-Built Drawings the locations of applicable sensors and meters.
- .28 Prepare a preliminary schedule, in conjunction with Division 25 Subcontractors for Division 22 pipe system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CA. Update the schedule as appropriate.
- .29 Notify the Consultant and CA when pipe system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify Consultant and CA, 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 CA has the scheduling information needed to efficiently execute the commissioning process.

## **PART 2- PRODUCTS**

- .1 NOT USED

## **PART 3- EXECUTION**

### **3.1 Submittals**

- .1 Section 22 Subcontractors shall provide submittal documentation relative to commissioning to the CA as requested by the CA. Refer to Section 01 91 00 Part 3.3 for additional Section 22 requirements.

### **3.2 Start-up of Equipment**

- .1 The plumbing Subcontractor(s) shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in 01 91 00. Division 22 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 Region.
- .2 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 CA and Consultant. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre functional checklists as soon as possible.
- .3 Prior to the start up of equipment the Division 22 Subcontractor shall arrange to have the manufacturer of all major equipment inspect the installation to ensure their equipment has been installed in accordance with their recommendations.
- .4 The supplier shall submit a written report of their findings.
- .5 Upon confirmation that the equipment has been installed in accordance with the manufacturer's recommendations the equipment may be started.
- .6 All equipment shall be started by the manufacturer's representative.

### **3.3 Pre-Functional Test Sheets**

- .1 Pre-functional test sheets contain items for Section 22 Subcontractors to perform. On each checklist, a column is provided that is to be completed by the Contractor assigning responsibility for that line item to a Subcontractor. Those executing the test sheets are only responsible to perform items that apply to the specific application at hand. These test sheets do not take the place of the manufacturer's recommended checkout and start-up procedures or report. Some checklist procedures may be redundant in relation to checkout procedures that will be documented on typical factory field checkout sheets. Double documenting may be required in those cases.
- .2 Refer to Section 01 91 00 for additional requirements regarding pre-functional test sheets, startup and initial checkout. Items that do not apply should be noted along with the reasons on the form. If this form is not used for documenting, one of similar rigor and clarity shall be used pending approval from the CA. Contractor's assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their Subcontractors are completed and checked off. "Contr." column or abbreviations in brackets to the right of an item refer to the Subcontractor responsible to verify completion of this item.

### **3.4 Operations and Maintenance Manuals**

- .1 The Contractor shall ensure that the Section 22 Subcontractors compile and prepare documentation for all equipment and systems covered in Section 22 and deliver it to the Contractor for inclusion in the O&M manuals.
- .2 The CA shall receive a copy of the O&M manuals for review.



### **3.5 Training of Region Personnel**

- .1 The Contractor shall coordinate and schedule training and ultimately to ensure that training is completed. Refer to Section 01 91 00 for additional details.
- .2 The CA will oversee and approve the content and adequacy of the training of Region personnel for commissioned equipment. Refer to Section 01 91 00 for additional details.
- .3 Mechanical Subcontractor. The Contractor shall ensure that the mechanical Subcontractor fulfills the following training responsibilities:
  - .1 Provide the CA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00, Part 3.8.
  - .2 Provide designated Region 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 Subcontractor 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 Subcontractor 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 Subcontractor 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:
    - .1 Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
    - .2 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.
    - .3 Discussion of relevant health and safety issues and concerns.
    - .4 Discussion of warranties and guarantees.
    - .5 Common troubleshooting problems and solutions.

- .6 Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
- .7 Discussion of any peculiarities of equipment installation or operation.
- .9 The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1-1989R, 1996 is recommended.
- .10 Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.
- .11 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.
- .12 The mechanical Subcontractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
- .13 Training shall occur after functional testing is complete, unless approved otherwise by the Consultant.

### **3.6 Deferred Testing**

- .1 Refer to Section 01 91 00, Part 3.9 for requirements of deferred testing.

### **3.7 WRITTEN WORK PRODUCTS**

- .1 Written work products of Section 22 Subcontractors will consist of the startup and initial checkout plan as described in Section 01 91 00, as well as completed startup, initial checkout and pre-functional test sheets.

**END OF SECTION**

## **PART 1 – GENERAL**

### **1.1 General**

- .1 The purpose of this section is to specify Division 23 responsibilities in the commissioning process.
- .2 The systems to be commissioned are listed in Section 01 91 00, Part 1.9.
- .3 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 in Section 01 91 00. Division 23 shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.
- .4 CA = Commissioning Agent, TAB = Test and Balance.

### **1.2 Responsibilities**

- .1 Mechanical Subcontractor. The Contractor shall ensure that the HVAC Subcontractor ("mechanical Subcontractor") complies with all requirements included in this Section and fulfills the following responsibilities during construction and acceptance phases (all references apply to commissioned equipment only):
  - .1 Documentation of all procedures performed shall be provided and forwarded to the Consultant. Written documentation must contain recorded test values of all mechanical tests performed per the individual product specification.
  - .2 The start-up service company shall be present during energization of the mechanical equipment. Site and equipment access must be provided by the mechanical Subcontractor.
  - .3 The Contractor shall supply a power source, specified by the start-up service company, for on-Site test equipment.
  - .4 The Contractor is to attend all factory witness testing required within the respective Specification Sections. The Contractor shall cover all their costs and include them in the Contract Price.
  - .5 Perform tests using qualified personnel. Provide necessary instruments and equipment.
  - .6 Include the cost of commissioning in the Contract Price, if not yet included.
  - .7 In each purchase order or subcontract written, include requirements for submittal data, O&M data and training.
  - .8 Attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the commissioning process.
  - .9 The Contractor and its Subcontractors shall provide normal cut sheets and shop drawing submittals to the CA of commissioned equipment. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of pre-functional and functional testing procedures.

- .1 Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any Region-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Region to keep the warranty in force clearly identified. In addition, the installation 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. This data request may be made prior to normal submittals.
- .10 Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CA for review.
- .11 The Contractor and its Subcontractors shall assist (along with the design Professional 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.
- .12 Provide assistance to the CA in preparation of the specific functional performance test procedures specified in Section 23. The Contractor shall ensure that its Subcontractors review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
- .13 Develop a full start-up and checkout plan using manufacturer's start-up procedures and the pre-functional test sheets from the CA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures and other requested equipment documentation to CA for review.
- .14 During the startup and checkout process, execute and document the mechanical-related portions of the pre-functional test sheets provided by the CA for all commissioned equipment.
- .15 Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.
- .16 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.
- .17 Perform functional performance testing under the direction of the CA for specified equipment in 01 91 00, Section 1.9. Assist the CA in interpreting the monitoring data, as necessary.
- .18 Correct deficiencies (differences between specified and observed performance) as interpreted by the CA and Consultant and retest the equipment.
- .19 Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
- .20 During construction, maintain as-built red-line drawings for all drawings and final CAD as-builts for Contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing). Prepare red-line As-Built Drawings for all drawings and final as-builts for Contractor-generated coordination drawings.

- .21 Provide training of the Region's operating personnel as specified.
- .22 Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
- .23 Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the Specifications.
- .24 Correct deficiencies and make necessary adjustments to O&M manuals and As-Built Drawings for applicable issues identified in any seasonal testing.
- .25 Assist and cooperate with the TAB Subcontractor and CA by:
  - .1 Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
  - .2 Including cost of sheaves and belts that may be required by TAB.
  - .3 Providing test holes in ducts and plenums where directed by TAB Subcontractor to allow air measurements and air balancing. Providing an approved plug.
  - .4 Providing temperature and pressure taps according to the Contract Documents for TAB and commissioning testing.
- .26 Install a P/T plug at each water sensor which is an input point to the control system.
- .27 List and clearly identify on the As-Built Drawings the locations of all air-flow stations.
- .28 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 CA. Update the schedule as appropriate.
- .29 Notify the Region's PM, Consultant and CA when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the Region's PM, Consultant and CA, 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 CA has the scheduling information needed to efficiently execute the commissioning process.
- .2 TAB Subcontractor: The Contractor shall ensure that the TAB Subcontractor complies with the following duties, in addition to those listed in 1.2.1:
  - .1 Six weeks prior to starting TAB, submit to the Contractor the qualifications of the Site technician for the project, including the name of the Subcontractors and facility managers of recent projects the technician on which was lead. The Region 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 Region's PM, CA, Consultant and the controls Subcontractor six weeks prior to starting the TAB. This plan will be developed after the TAB Subcontractor has some familiarity with the control system. The submitted plan will include:
    - .1 Certification that the TAB Subcontractor has reviewed the construction documents and the systems with the design Professional Engineers and Contractor to sufficiently understand the design intent for each system.

- .2 An explanation of the intended use of the building control system. The controls Subcontractor will comment on feasibility of the plan.
- .3 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.
- .4 Discussion of what notations and markings will be made on the duct and piping drawings during the process.
- .5 Final test report forms to be used.
- .6 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 strengtheners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the water side.
- .7 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.
- .8 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) pilot traverse, SA or RA flow stations. Water: pump curves, circuit setter, flow station, ultrasonic, etc.).
- .9 The identification and types of measurement instruments to be used and their most recent calibration date.
- .10 Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and provide methods to verify this.
- .11 Confirmation that TAB understands the outside air ventilation criteria under all conditions.
- .12 Details of whether and how minimum outside air cfm will be verified and set and for what level (total building, zone, etc.).
- .13 Details of how building static and exhaust fan / relief damper capacity will be checked.
- .14 Proposed selection points for sound measurements and sound measurement methods.
- .15 Details of methods for making any specified coil or other system plant capacity measurements.
- .16 Details of any TAB work to be done in phases (by floor, etc.), or of areas to be built out later.
- .17 Details regarding specified deferred or seasonal TAB work.
- .18 Details of any specified false loading of systems to complete TAB work.
- .19 Details of all exhaust fan balancing and capacity verifications, including any required room pressure differentials.
- .20 Details of any required interstitial cavity differential pressure measurements and calculations.

- .21 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).
- .22 Plan for formal progress reports (scope and frequency).
- .23 Plan for formal deficiency reports (scope, frequency and distribution).
- .3 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 Region's PM, CA and Consultant at least twice a week.
- .4 Communicate in writing to the controls Subcontractor all setpoint and parameter changes made or problems and discrepancies identified during TAB which affect the control system setup and operation.
- .5 Provide a draft TAB report within two weeks of completion. A copy shall be provided to the CA. 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.
- .6 Provide the CA with any requested data, gathered, but not shown on the draft reports.
- .7 Provide a final TAB report for the CA with details, as in the draft.
- .8 Conduct functional performance tests and checks on the original TAB as specified for TAB in this Section.

## **PART 2- PRODUCTS**

- .1 NOT USED

## **PART 3- EXECUTION**

### **3.1 Submittals**

- .1 The Contractor shall ensure that Section 23 Subcontractors provide submittal documentation relative to commissioning to the CA as requested by the CA. Refer to Section 01 91 00 Part 3.3 for additional Section 23 requirements.

### **3.2 Start-up of Equipment**

- .1 The HVAC Subcontractor(s) shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in 01 91 00. 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 Agent or the Region.

- .2 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 CA and Consultant. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre functional checklists as soon as possible.
- .3 Prior to the start up of equipment the Division 23 Subcontractor shall arrange to have the manufacturer of all major equipment inspect the installation to ensure their equipment has been installed in accordance with their recommendations.
- .4 The supplier shall submit a written report of their findings.
- .5 Upon confirmation that the equipment has been installed in accordance with the manufacturer's recommendations the equipment may be started.
- .6 All equipment shall be started by the manufacturer's representative.

### **3.3 Pre-Functional Test Sheets**

- .1 Pre-functional test sheets contain items for Section 23 Subcontractors to perform. On each checklist, a column is provided that is to be completed by the Contractor assigning responsibility for that line item to a Subcontractor. Those executing the test sheets are only responsible to perform items that apply to the specific application at hand. These test sheets do not take the place of the manufacturer's recommended checkout and start-up procedures or report. Some checklist procedures may be redundant in relation to checkout procedures that will be documented on typical factory field checkout sheets. Double documenting may be required in those cases.
- .2 Refer to Section 01 91 00 for additional requirements regarding pre-functional test sheets, startup and initial checkout. Items that do not apply should be noted along with the reasons on the form. If this form is not used for documenting, one of similar rigor and clarity shall be used pending approval from the CA. The Contractor's assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their Subcontractors are completed and checked off. "Contr." column or abbreviations in brackets to the right of an item refer to the Subcontractor responsible to verify completion of this item.

### **3.4 Operations and Maintenance Manuals**

- .1 The Contractor shall ensure that Section 23 Subcontractors compile and prepare documentation for all equipment and systems covered in Section 23 and deliver it to the Contractor for inclusion in the O&M manuals
- .2 The CA shall receive a copy of the O&M manuals for review.

### **3.5 Training of Region Personnel**

- .1 The Contractor shall coordinate and schedule training and ultimately to ensure that training is completed. Refer to Section 01 91 00 for additional details.
- .2 The CA will oversee and approve the content and adequacy of the training of the Region personnel for commissioned equipment. Refer to Section 01 91 00 for additional details.



- .3 Mechanical Subcontractor. The Contractor shall ensure that the mechanical Subcontractor fulfills the following training responsibilities:
- .1 Provide the CA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00, Part 3.8.
  - .2 Provide the designated Region 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 Subcontractor 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 Subcontractor 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 Subcontractor 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:
    - .1 Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
    - .2 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.
    - .3 Discussion of relevant health and safety issues and concerns.
    - .4 Discussion of warranties and guarantees.
    - .5 Common troubleshooting problems and solutions.
    - .6 Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
    - .7 Discussion of any peculiarities of equipment installation or operation.
  - .9 The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1-1989R, 1996 is recommended.

- .10 Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.
- .11 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.
- .12 The mechanical Subcontractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
- .13 Training shall occur after functional testing is complete, unless approved otherwise by the -Region's PM

### **3.6 Deferred Testing**

- .1 Refer to Section 01 91 00, Part 3.9 for requirements of deferred testing.

### **3.7 WRITTEN WORK PRODUCTS**

- .1 Written work products of Section 23 Subcontractors will consist of the startup and initial checkout plan as described in Section 01 91 00, as well as completed startup, initial checkout and pre-functional test sheets.

**END OF SECTION**

## **PART 1 – GENERAL**

### **1.1 General**

- .1 The purpose of this section is to specify Division 25 responsibilities in the commissioning process.
- .2 The systems to be commissioned are listed in Section 01 91 00, Part 1.9.
- .3 Commissioning requires the participation of Division 25 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 25 shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.
- .4 CA = Commissioning Agent, TAB = Test and Balance.

### **1.2 Responsibilities**

- .1 Controls Subcontractor. The Contractor shall ensure that the controls Subcontractor complies with all requirements included in this Section and fulfills the following responsibilities during construction and acceptance phases (all references apply to commissioned equipment only):
  - .1 Sequences of Operation Submittals. The controls Subcontractor'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:
    - .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 BAS, 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 setpoints 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.
  - .17 Schedules, if known.
  - .18 To facilitate referencing in testing procedures, all sequences shall be written in concise statements
  - .2 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 (i.e. sensors, dampers, coils, valves, etc.)
    - .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:
      - .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)
      - .9 Key:
        - Point Description: DB temp, airflow, etc.
        - Control or Setpoint: Point that controls equipment and can have its setpoint changed (OSA, SAT, etc.)
        - 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).
        - Monitoring Point: Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.
        - Calculated Point: "Virtual" point generated from calculations of other point values.
- The Controls Contractor shall keep the CA informed of all changes to this list during programming and setup.

- .3 As-Built Controls Package - An updated as-built version of the Controls Drawings and Sequence of Operation, which is to include all items identified above, shall be provided to the CA and included in the final controls O&M manual submittal.
- .4 Assist in TAB Work- The Controls Subcontractor shall assist in the TAB work through the following:
  - .1 Meet with the TAB Subcontractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB Subcontractor any needed unique instruments for setting terminal unit boxes and instruct the TAB Subcontractor 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 completed and approved by the CA prior to TAB.
  - .3 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.
- .5 Required assistance to the CA - Assist and cooperate with the CA in the following manner:
  - .1 Using a skilled technician who is familiar with the building, execute the functional testing of the all equipment specified in Section 01 91 00 under direction of the CA. Provide two-way radios during the testing.
  - .2 Execute all control system trend logs specified in Section 01 91 00.
  - .3 Written Plan - The controls Subcontractor 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 01 91 00. At minimum, the plan shall include the following for each type of equipment controlled by the automatic controls:
    - .1 System name.
    - .2 List of devices.
    - .3 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.

- .4 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.
- .5 A description of the instrumentation required for testing.
- .6 Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the CA and TAB Subcontractor for this determination.
- .6 Checkout Certification - Provide a signed and dated certification report to the CA and Consultant upon completion of the checkout of each controlled device, equipment and system prior to functional testing. This report shall serve as confirmation that all system programming is complete in accordance to the Contract Documents, with the exception functional testing requirements. The checkout report shall also include complete point-to-point verification and sequence of operations verification checklists.
- .7 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).

## **PART 2- PRODUCTS**

- .1 NOT USED

## **PART 3- EXECUTION**

### **3.1 Submittals**

- .1 Section 25 Subcontractors shall provide submittal documentation relative to commissioning to the CA as requested by the CA. Refer to Section 01 91 00 Part 3.3 for additional Section 25 requirements.

### **3.2 Start-up of Equipment**

- .1 The Controls Contractor shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in Section 01 91 00, Part 3.4. Section 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 CA or the Region.
- .2 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 CA and the Consultant. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre functional checklists as soon as possible.
- .3 Prior to the start up of equipment the Division 25 Subcontractor shall arrange to have the manufacturer of all major equipment inspect the installation to ensure their equipment has been installed in accordance with their recommendations.
- .4 The supplier shall submit a written report of their findings.
- .5 Upon confirmation that the equipment has been installed in accordance with the manufacturer's recommendations the equipment may be started.

- .6 All equipment shall be started by the manufacturer's representative.

### **3.3 Pre-Functional Test Sheets**

- .1 Pre-functional test sheets contain items for Section 25 Subcontractors to perform. On each checklist, a column is provided that is to be completed by the Contractor assigning responsibility for that line item to a Subcontractor. Those executing the test sheets are only responsible to perform items that apply to the specific application at hand. These test sheets do not take the place of the manufacturer's recommended checkout and start-up procedures or report. Some checklist procedures may be redundant in relation to checkout procedures that will be documented on typical factory field checkout sheets. Double documenting may be required in those cases.
- .2 Refer to Section 01 91 00 for additional requirements regarding pre-functional test sheets, startup and initial checkout. Items that do not apply should be noted along with the reasons on the form. If this form is not used for documenting, one of similar rigor and clarity shall be used pending approval from the CA. Contractor's assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their Subcontractors are completed and checked off. "Contr." column or abbreviations in brackets to the right of an item refer to the Subcontractor responsible to verify completion of this item.

### **3.4 Operations and Maintenance Manuals**

- .1 The Contractor shall ensure that the Section 25 Subcontractors compile and prepare documentation for all equipment and systems covered in Section 25 and deliver it to the Contractor for inclusion in the O&M manuals
- .2 The CA shall receive a copy of the O&M manuals for review.

### **3.5 Training of Region Personnel**

- .1 The Contractor shall coordinate and schedule training and ultimately to ensure that training is completed. Refer to Section 01 91 00 for additional details.
- .2 The CA will oversee and approve the content and adequacy of the training of Region personnel for commissioned equipment. Refer to Section 01 91 00 for additional details.
- .3 Controls Subcontractor. The Contractor shall ensure that the controls Subcontractor fulfills the following training responsibilities:
  - .1 Provide the CA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00, Part 3.8.
  - .2 Provide designated Region personnel with comprehensive training in the understanding of the systems and the operation and maintenance of the BAS system.
  - .3 Training shall start with classroom sessions, if necessary, followed by hands on training on the BAS, 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 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.
- .6 Training shall include:
  - .1 Use the printed installation, operation and maintenance instruction material included in the O&M manuals.
  - .2 Include 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.
  - .3 Discuss relevant health and safety issues and concerns.
  - .4 Discuss warranties and guarantees.
  - .5 Cover common troubleshooting problems and solutions.
  - .6 Explain information included in the O&M manuals and the location of all plans and manuals in the facility.
  - .7 Discuss any peculiarities of equipment installation or operation.
  - .8 Classroom sessions shall include the use of overhead projections, slides, video and audio taped material as might be appropriate.
- .7 Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and maintenance of all pieces of equipment.
- .8 The controls Subcontractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
- .9 Training shall occur after functional testing is complete, unless approved otherwise by the the Region's PM.

### **3.6 Deferred Testing**

- .1 Refer to Section 01 91 00, Part 3.9 for requirements of deferred testing.

### **3.7 WRITTEN WORK PRODUCTS**

- .1 Written work products of Section 25 Subcontractors will consist of the startup and initial checkout plan as described in Section 01 91 00, as well as completed startup, initial checkout and pre-functional test sheets.

**END OF SECTION**



## **PART 1 – GENERAL**

### **1.1 General**

- .1 The purpose of this section is to specify Division 26 responsibilities in the commissioning process.
- .2 The systems to be commissioned are listed in Section 01 91 00, Part 1.9.
- .3 Commissioning requires the participation of Division 26 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 26 shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.
- .4 CA = Commissioning Agent.

### **1.2 Responsibilities**

- .1 Electrical Subcontractors. The Contractor shall ensure that the electrical Subcontractor complies with all requirements included in this Section and fulfills the following responsibilities (all references apply to commissioned equipment only):
  - .1 Documentation of all procedures performed shall be provided and forwarded to the Professional Engineer. Written documentation must contain recorded test values of all electrical tests performed per the individual product specification.
  - .2 The start-up service company shall be present during energization of the electrical equipment. Site and equipment access must be provided by the electrical subcontractor.
  - .3 The Contractor shall supply a power source, specified by the start-up service company, for on-Site test equipment.
  - .4 The Contractor is to attend all factory witness testing required within the respective Specification Sections. The Contractor shall cover all their costs and include them in their bid.
  - .5 Perform tests using qualified personnel. Provide necessary instruments and equipment.
  - .6 Include the cost of commissioning in the Contract Price, if not yet let.
  - .7 In each purchase order or subcontract written, include requirements for submittal data, O&M data and training.
  - .8 Attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the commissioning process.
  - .9 The Contractor shall provide normal cut sheets and shop drawing submittals to the CA of commissioned equipment. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of pre-functional and functional testing procedures.

- .1 Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any Region-contracted tests, full factory testing reports (if any), and full warranty information including all responsibilities of the Region to keep the warranty in force clearly identified. In addition, the installation 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 Authority may request further documentation necessary for the commissioning process. This data request may be made prior to normal submittals.
- .10 Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CA for review.
- .11 Contractors shall assist (along with the design Professional 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.
- .12 Provide assistance to the CA in preparation of the specific functional performance test procedures specified in Section 26. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
- .13 Develop a full start-up and checkout plan using manufacturer's start-up procedures and the pre-functional test sheets from the CA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures and other requested equipment documentation to CA for review.
- .14 During the startup and checkout process, execute and document the electrical-related portions of the pre-functional test sheets provided by the CA for all commissioned equipment.
- .15 Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.
- .16 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.
- .17 Perform functional performance testing under the direction of the CA for specified equipment in 01 91 00 Section 1.9. Assist the CA in interpreting the monitoring data, as necessary.
- .18 Correct deficiencies (differences between specified and observed performance) as interpreted by the CA and the Consultant and retest the equipment.
- .19 Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
- .20 During construction, maintain as-built red-line drawings for all drawings. Update after completion of commissioning (excluding deferred testing). Prepare red-line As-Built Drawings for all drawings.

- .21 Provide training of the Region's operating personnel as specified in Section 3.8.
- .22 Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
- .23 Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the Specifications.
- .24 Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

## **PART 2- PRODUCTS**

- .1 NOT USED

## **PART 3- EXECUTION**

### **3.1 Submittals**

- .1 The Contractor shall ensure that Section 26 Subcontractors provide submittal documentation relative to commissioning to the CA as requested by the CA. Refer to Section 01 91 00 Part 3.3 for additional Section 26 requirements.

### **3.2 Start-up of Equipment**

- .1 The electrical Subcontractor(s) shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in Section 01 91 00, Part 3.4. Section 26 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 Region.
- .2 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 CA and Consultant. Beginning system testing before full completion, does not relieve the Contractor from fully completing the system, including all Pre Functional test sheets as soon as possible.
- .3 All equipment shall be started by the manufacturer's representative.

### **3.3 Pre-Functional Test Sheets**

- .1 Pre-functional test sheets contain items for Section 26 Contractors to perform. On each checklist, a column is provided that is to be completed by the contractor assigning responsibility for that line item to a Subcontractor. Those executing the test sheets are only responsible to perform items that apply to the specific application at hand. These test sheets do not take the place of the manufacturer's recommended checkout and start-up procedures or report. Some checklist procedures may be redundant in relation to checkout procedures that will be documented on typical factory field checkout sheets. Double documenting may be required in those cases.

- .2 Refer to Section 01 91 00 for additional requirements regarding pre-functional test sheets, startup and initial checkout. Items that do not apply should be noted along with the reasons on the form. If this form is not used for documenting, one of similar rigor and clarity shall be used pending approval from the CA. Contractor's assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off. "Contr." column or abbreviations in brackets to the right of an item refer to the contractor responsible to verify completion of this item. A/E = Architect/Engineer, All = all Contractors, CA = Commissioning Agent, CC = Controls Contractor, EC = Electrical Contractor, PM/GC = General Contractor, MC = Mechanical Contractor, SC = Sheet Metal Contractor, TAB = Test and Balance Contractor.

### **3.4 Operations and Maintenance Manuals**

- .1 The Contractor shall ensure that the Section 26 Subcontractors compile and prepare documentation for all equipment and systems covered in Section 26 and deliver it to the Contractor for inclusion in the O&M manuals
- .2 The CA shall receive a copy of the O&M manuals for review.

### **3.5 Training of Region Personnel**

- .1 The Contractor shall coordinate and schedule training and ultimately to ensure the training is completed. Refer to Section 01 91 00 for additional details.
- .2 The CA will oversee and approve the content and adequacy of the training of Region personnel for commissioned equipment Refer to Section 01 91 00 for additional details.
- .3 Electrical Subcontractor: The Contractor shall ensure that the electrical Subcontractor fulfills the following training responsibilities:
  - .1 Provide the CA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00, Part 3.8.
  - .2 Provide designated Region personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned electrical equipment or system.
  - .3 Training shall start with classroom sessions, if necessary, 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 Subcontractor 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 Subcontractor 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.
  - .6 The training sessions shall follow the outline in the Table of Contents of the Operation and Maintenance (O&M) manual and illustrate whenever possible the use of the O&M manuals for reference.

- .7 Training shall include:
  - .1 Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
  - .2 Include 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.
  - .3 Discuss relevant health and safety issues and concerns.
  - .4 Discuss warranties and guarantees.
  - .5 Cover common troubleshooting problems and solutions.
  - .6 Explain information included in the O&M manuals and the location of all plans and manuals in the facility.
  - .7 Discuss any peculiarities of equipment installation or operation.
- .8 Classroom sessions shall include the use of overhead projections, slides, video and 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 maintenance of all pieces of equipment.
- .10 The electrical Subcontractor 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 accepted otherwise by the Consultant.

### **3.6 Deferred Testing**

- .1 Refer to Section 01 91 00, Part 3.9 for requirements of deferred testing.

### **3.7 WRITTEN WORK PRODUCTS**

- .1 Written work products of Section 26 Subcontractors will consist of the startup and initial checkout plan as described in Section 01 91 00, as well as completed startup, initial checkout and pre-functional test sheets.

**END OF SECTION**