SECTION 019100 – COMMISSIONING

1. GENERAL
	* + 1. DESCRIPTION

Commissioning Definition: Commissioning is a systematic process of ensuring and documenting that all building systems perform interactively according to the design intent and the owner’s operational needs. The commissioning process includes documentation, equipment startup, control system calibration, testing, balancing, performance testing, and training.

* + - * 1. Commissioning is intended to achieve the following specific objectives according to the Contract Documents:

Verify that applicable equipment and systems are installed according to the manufacturer’s recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.

Verify and document proper performance of equipment and systems.

Verify that complete O&M documentation is turned over to OHSU Facilities teams in a formal process.

Verify that the OHSU Facilities teams are adequately trained.

* + - * 1. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.
			1. DEFINTIONS

A/E- Architect and Engineering Team

CxA- Commissioning Authority

CC- Controls Contractor

FPC- Fire Protection Contractor

FPT- Functional Performance Test

GC- General Contractor

MEP – Mechanical, Electrical, and Plumbing

O&M- Operation and Maintenance

PFC- Pre-functional Checklist

PM - OHSU Project Manager

SO – OHSU System Owner

TAB- Test and Balance

* + - 1. COORDINATION
				1. Commissioning Team: The members of the commissioning team consist of the Commissioning Authority (CxA), the owner’s designated Project Manager (PM), OHSU System Owner (SO), the General Contractor (GC or Contractor), the architect and design engineers (A/E), the MEP subcontractors, the TAB representative, the Controls Contractor (CC), any other installing subcontractors or suppliers of equipment.
				2. Management: The CxA is hired by the Owner directly. The CxA directs and coordinates the commissioning activities. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents. The CxA’s responsibilities are the same regardless of who hired the CxA.
				3. Scheduling: The CxA will work with the GC according to established protocols to schedule the commissioning activities. The CxA will provide sufficient notice to the PM and GC for scheduling commissioning activities. The GC will integrate all commissioning activities into the master schedule. All parties will address scheduling on an ongoing basis and make necessary notifications in a timely manner in order to expedite the commissioning process.
			2. COMMISSIONING PROCESS

Commissioning Process: The following narrative provides a brief overview of the typical commissioning tasks during construction and the general order in which they occur.

Commissioning during construction begins with a scoping meeting conducted by the CxA where the commissioning process is reviewed with the commissioning team members.

Additional meetings will be required throughout construction, scheduled by the CxA with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.

Equipment documentation is submitted to the CxA during normal submittals, including detailed start-up procedures.

The CxA works with the Subs to develop startup plans and startup documentation formats, which may include providing the Subs with prefunctional checklists to be completed during the startup process.

In general, the checkout and performance verification proceeds from simple to complex; from component level to equipment to systems and intersystem levels with prefunctional checklists being completed before functional testing.

The Subs, under their own direction, execute and document the prefunctional checklists and perform startup and initial checkout. The CxA documents that the checklists and startup were completed according to approved plans, and may witness startup of selected systems and equipment.

The CxA develops specific equipment and system functional testing procedures. The Subs review the procedures.

The procedures are executed and documented by the CxA, with the assistance of the Subs as necessary.

Items of non-compliance in material, installation, programming, calibration, start-up or setup are corrected at the Sub’s expense and the system retested.

The CxA reviews O&M’s for all commissioned systems for completeness.

The CxA reviews and approves training plans/agenda for training provided by the Subs (for commissioned equipment), and verifies that training was completed as per the contract documents.

The CxA issues report of commissioning process and results.

The CxA performs a Near-Warranty End or Post Occupancy Review approximately 6 and 11 months into the 12-month warranty period.

* + - 1. RELATED WORK

Specific commissioning requirements are given in the following sections of these specifications. All of the following sections apply to the Work of this section.

21 08 00 – Fire Suppression Systems Commissioning Requirements

22 08 00 – Plumbing System Commissioning Requirements

23 08 00 – HVAC Systems Commissioning Requirements

26 08 00 - Electrical Systems Commissioning Requirements

27 08 00 - Communication System Commissioning Requirements

* + - 1. RESPONSIBILITIES

The responsibilities of various parties in the commissioning process are provided in this section. It is noted that the services for the Commissioning Authority, Project Manager, Construction Manager, Architect, and HVAC mechanical and electrical designers/engineers are not provided for in this contract. That is, the Contractor is not responsible for providing their services. Their responsibilities are listed here to clarify the commissioning process.

All Parties

Follow the Commissioning Plan and Cx Specification requirements.

Attend commissioning meetings, as necessary.

Architect

Attend the commissioning scoping meeting and selected commissioning team meetings.

Perform normal submittal review, construction observation, as-built drawing preparation, O&M manual preparation, etc., as contracted.

Provide any design narrative documentation requested by the CxA.

Coordinate resolution of system deficiencies identified during commissioning, according to the contract documents.

Prepare and submit final as-built design intent documentation for inclusion in the O&M manuals. Review and approve the O&M manuals.

Coordinate resolution of design non-conformance and design deficiencies identified during warranty-period commissioning.

Mechanical, Plumbing and Electrical Designers/Engineers

Perform normal submittal review, construction observation, as-built drawing preparation, etc., as contracted.

Update final basis of design documentation for inclusion in the Systems Manual.

The designers shall assist (along with the contractors) 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.

Attend commissioning scoping meetings and other selected commissioning team meetings.

Participate in the resolution of system deficiencies identified during commissioning, according to the contract documents.

Provide one-line system diagrams to the CxA for use in preparing the Systems Manual.

Prepare and submit the final as-built design intent and operating parameters documentation for inclusion in the O&M manuals. Review and approve the O&M manuals.

Participate in the resolution of non-compliance, non-conformance and design deficiencies identified during commissioning during warranty-period commissioning.

Commissioning Authority (CxA)

The CxA is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CxA may assist with problem-solving, non-conformance or deficiencies, but ultimately that responsibility resides with the general contractor and the A/E. The primary role of the CxA 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 Contractors 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 CxA.

The CxA will provide information to the US Green Building Council web site in support of satisfying the LEED Energy and Atmosphere (EA) prerequisite 1, Fundamental Commissioning of Building Energy Systems; and EA credit 3, Enhanced Commissioning. The CxA is not the LEED Coordinator for the project.

Coordinate the commissioning work and, with the GC and PM, ensure that commissioning activities are being scheduled into the master schedule.

Plan and conduct a commissioning scoping meeting and other commissioning meetings.

Request and review additional information required to perform commissioning tasks, including O&M materials, contractor start-up and checkout procedures.

Before startup, gather and review the current control sequences and interlocks and work with contractors and design engineers until sufficient clarity has been obtained, in writing, to be able to write detailed testing procedures.

Review and approve normal Contractor submittals applicable to systems being commissioned for compliance with commissioning needs, concurrent with the A/E reviews.

Write and distribute pre-functional tests and checklists.

Perform site visits, as necessary, to observe component and system installations. Attend selected planning and job-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.

Approve systems startup by reviewing start-up reports and by selected site observation.

Oversee sufficient functional testing of the control system and approve it to be used for TAB, before TAB is executed.

With necessary assistance and review from installing contractors, write the functional testing procedures for equipment and systems. This may include energy management control system trending, stand-alone data logger monitoring or manual functional testing. Submit to PM for review, and for approval if required.

Analyze any functional performance trend logs and monitoring data to verify performance.

Coordinate, witness and approve manual functional tests performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved.

Perform or witness functional test procedures on the commissioned equipment.

Maintain a master deficiency and resolution log and a separate testing record. Provide the PM with written progress reports and test results with recommended actions.

Monitor and approve the training plans for the Owner’s operating personnel on commissioned systems.

Review and approve the preparation of the O&M manuals for commissioned systems.

Provide a Systems Manual for all commissioned systems.

Provide a final commissioning report (as described in this section).

Coordinate and supervise required seasonal or deferred testing and deficiency corrections.

Return to the site at 6 and 11 months into the 12 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 resolving outstanding problems.

Owner’s Project Manager (PM)

Manage the contract of the A/E and of the GC.

Provide final approval for the completion of the commissioning work.

Ensure that any seasonal or deferred testing and any deficiency issues are addressed.

General Contractor (GC)

Facilitate the coordination of the commissioning work by the CxA, and with the CxA ensure that commissioning activities are being scheduled into the master schedule.

Furnish a copy of all construction documents, addenda, change orders and approved submittals and shop drawings related to commissioned equipment to the CxA.

In each purchase order or subcontract written, include requirements for submittal data, O&M data, commissioning tasks and training.

Ensure that all Subs execute their commissioning responsibilities according to the Contract Documents and schedule.

A representative shall attend a commissioning scoping meeting and other necessary meetings scheduled by the CxA to facilitate the Cx process.

Coordinate the training of owner personnel.

Prepare O&M manuals, according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

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.

Equipment Suppliers

Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force.

Assist in equipment testing per agreements with Subs.

Include all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents in the base bid price to the Contractor, except for stand-alone data logging equipment that may be used by the CxA.

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.

Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

Review test procedures for equipment installed by factory representatives.

* + - 1. SYSTEMS TO BE COMMISSIONED

The following equipment and associated systems will be commissioned in this project:

**[Note to A/E: Under each Division number applicable, list systems that will be included in the project and commissioned. There is a place to add more detail to these lists in the Fire Protection, Plumbing, HVAC, and Electrical Specifications. Some examples are listed in red.]**

Division 11: Commercial Appliances

Food service refrigerators

Food service freezers

Clinical refrigerators and freezers

Blood bank refrigeration

Division 21: Fire Protection Systems

Fire pump / Jockey pump

Pre-action systems

Division 22: Plumbing Systems

Domestic Cold water

Domestic Hot water

Water Heaters

Recirculation system

Metering

Booster pump

Sump pumps

Fuel oil

Medical Gas systems

Division 23: HVAC Systems

Primary Systems

Air terminal units

Induction units

Fan coil units

Unit heaters

Air-handling units

Energy recovery units

Pumps

Exhaust system

Chilled water system/piping

Heating water system/piping

Steam system

Humidifiers

Fire and smoke dampers

Ductwork and distribution

Refrigerant detection system (Chiller Room)

Special applications (test room pressurization)

Operating rooms (Anesthetizing Locations)

Airborne infection isolation (All Rooms)

Protective environment rooms (PE Rooms)

Sterile processing

Pharmacy

Life Safety Systems

Stair pressurization system

Elevator shaft pressurization

Smoke control

Controls Systems

Workstations

System graphics and dashboards

Networks

Controllers

Sensors

Actuators

Meters

Division 26: Electrical Systems

Electrical Metering Systems

Static Uninterruptible power supplies & controls

Engine Generators & controls

Automatic transfer switches & controls

Interior lighting controls, daylighing and occupancy sensors

Exterior lighting controls

Electrical System Overcurrent Protective Device Coordination

Egress Lighting levels (elevator lobby, interior emergency, and parking emergency)

Division 27: Communication Systems

Nurse call

Security (intersystem connectivity)

Division 28: Electronic Safety and Security Systems

Fire alarm system

Interface with life safety systems

Interface with fire protection system

Interface with HVAC system

Interface with elevators

Interface with access controls system

Interface with security systems

* + - * 1. General references to equipment will refer to the above systems and their components.
1. PRODUCTS
	* + 1. TEST EQUIPMENT
				1. All standard testing equipment required to perform startup and initial checkout and required functional testing shall be provided by the Division contractor for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC system and controls system in Division 23, except for equipment specific to and used by the TAB contractor in their commissioning responsibilities.
				2. 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 base bid price to the Contractor and left on site, except for stand-alone data-logging equipment that may be used by the CxA.
				3. Data-logging equipment and software required to test equipment will be provided by the CxA for use by the CxA only, and shall not become the property of the Owner.
				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. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of ±0.5F and a resolution of ± 0.2F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. 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.
2. EXECUTION
	* + 1. MEETINGS

Scoping Meeting: The CxA will schedule, plan and conduct a commissioning scoping meeting with the entire commissioning team in attendance. Information gathered from this meeting will be used by the CxA to revise the Draft Commissioning Plan to its “final” version.

Miscellaneous Meetings: CxA may attend regular construction meetings to keep informed of project progress & coordinate the commissioning activities. Other meetings will be planned and conducted by the CxA as construction progresses. These meetings will cover coordination, deficiency resolution and planning issues with particular Subs. The CxA will plan these meetings and will minimize unnecessary time being spent by Subs.

* + - 1. REPORTING

The CxA will regularly communicate with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling changes through memos, progress reports, etc.

A final summary report by the CxA will be provided to the PM, focusing on evaluating commissioning process issues and identifying areas where the process could be improved. All acquired documentation, logs, minutes, reports, deficiency lists, communications, findings, unresolved issues, etc., will be compiled in appendices and provided with the summary report.

* + - 1. SUBMITTALS

The CxA will provide appropriate contractors with a specific request for the type of submittal documentation the CxA requires to facilitate the commissioning work. These requests will be integrated into the normal submittal process and protocol of the construction team. At minimum, the request will include the manufacturer and model number, 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 owner contracted tests. 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 Authority. All documentation requested by the CxA will be included by the Subs in their O&M manual contributions.

The CxA may request additional design narrative from the A/E and Controls Contractor, depending on the completeness of the design intent documentation and sequences provided with the Specifications.

The Commissioning authority will review submittals related to the commissioned equipment for conformance to the Contract Documents as it relates to the commissioning process, to the functional performance of the equipment and adequacy for developing test procedures. This review is intended primarily to aid in the development of functional testing procedures and only secondarily to verify compliance with equipment specifications, which is the A/E’s responsibility. The Commissioning authority will notify the GC, PM or A/E as requested, of items missing or areas that are not in conformance with Contract Documents and which requires resubmission.

These submittals to the CxA do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the Contractor, though the CxA will review and approve them.

* + - 1. START-UP, PREFUNCTIONAL CHECKLIST AND INITIAL CHECKOUT

The following procedures apply to all equipment to be commissioned, according to Section 1.06, Systems to be Commissioned.

Prefunctional checklists are necessary to ensure that the equipment and systems are operational. It ensures that functional testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment must receive a full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional testing of equipment or subsystems of the given system. Attachment A is an example of an acceptable format for the PFC. Other formats may be used with the permission of the PM.

Start-up and Initial Checkout Plan: The CxA shall assist the contractor in developing pre-functional checklists and a detailed start-up plan for all commissioned equipment. The primary role of the CxA in this process is ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed.

The subcontractor responsible for the purchase of the equipment develops the full start-up plan. The plan will include checklists 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:

The CxA’s, contractor’s or manufacturer’s prefunctional checklists.

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.

The manufacturer’s normally used field checkout sheets.

The subcontractor submits the full startup plan to the CxA for review and approval.

The CxA reviews and approves the procedures and the format for documenting them, noting any procedures that need to be added.

The full start-up procedures and the approval form may be provided to the PM for review and approval, depending on management protocol.

Execution of Prefunctional Checklists and Startup.

Four weeks prior to startup, the Subs and vendors schedule startup and checkout with the PM, GC and CxA. The performance of the prefunctional checklists, startup and checkout are directed and executed by the Sub or vendor. When checking off prefunctional checklists, signatures may be required of other Subs for verification of completion of their work.

The CxA shall verify compliance on at least 20% of equipment requiring formal start-up procedures.

The Subs and vendors shall execute startup and provide the CxA with a signed and dated copy of the completed start-up and prefunctional tests and checklists.

Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

* + - * 1. Deficiencies, Non-Conformance and Approval in Checklists and Startup.

The Subs shall clearly list any outstanding items of the initial start-up and prefunctional 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 CxA within two days of test completion.

The CxA reviews the report and submits either a non-compliance report or an approval form to the Sub or PM. The CxA shall work with the Subs and vendors to correct and retest deficiencies or uncompleted items. The CxA will involve the PM, GC and others as necessary. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CxA 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 CxA recommends approval of the execution of the checklists and startup of each system to the PM using a standard form.

Items left incomplete, which later cause deficiencies or delays during functional testing may result in back-charges to the responsible party. Refer to Part 3.06 herein for details.

* + - 1. FUNCTIONAL TESTING

This sub-section applies to all commissioning functional testing for all divisions.

Objectives and Scope: The objective of functional 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.

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.

Development of Test Procedures: Before test procedures are written, the CxA 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. The CxA shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Each Sub or vendor shall provide limited assistance to the CxA in developing the procedures (answering questions about equipment, operation, sequences, etc.). Prior to execution, the CxA 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 CxA may submit the tests to the A/E for review, if requested.

Functional tests may also be written and performed by the contractor and witnessed by the CxA. Fire protection and emergency generator sequences would be an example of this. In these cases, a test plan would be submitted by the contractor and approved by the CxA prior to testing.

Test Methods

Functional 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.

Simulated Conditions: Simulating conditions (not by an overwritten value) shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.

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 dryer rather than overwriting the value or by altering the appropriate set point to see the desired response. Before simulating conditions or overwriting values, sensors, transducers and devices shall have been calibrated.

Altering Set Points: Rather than overwriting sensor values, and when simulating conditions is difficult, altering set points to test a sequence is acceptable. For example, to see the AC compressor lockout work at an outside air temperature below 55F, when the outside air temperature is above 55F, temporarily change the lockout set point to be 2F above the current outside air temperature.

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 prefunctional testing.

Setup: Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. At completion of the test, the CxA shall return all affected building equipment and systems, due to temporary modifications, to their pre-test condition.

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 prefunctional checklist execution.

A common sampling strategy is the “xx% Sampling—yy% Failure Rule”, 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.

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.”

If 10% (yy) of the units in the first sample fail the functional tests, test another 20% of the group (the second sample).

If 10% of the units in the second sample fail, test all remaining units in the whole group.

If at any point, frequent failures are occurring and testing is becoming more troubleshooting than verification, the CxA 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.

* + - * 1. Coordination and Scheduling.

The Subs shall provide sufficient notice to the CxA regarding their completion schedule for the prefunctional checklists and startup of all equipment and systems. The Controls Contractor will provide written notification that they have completed all required prefunctional checklists, wire terminations, point-to-point verification, sensor calibration verification, sequence/programming verification checks, all graphics, trend logs active and that their system(s) are complete and ready for functional testing before testing will proceed. The CxA will schedule functional tests through the PM, GC and affected Subs. The CxA shall develop, execute and document the functional testing of all equipment and systems.

In general, functional testing is conducted after prefunctional testing and startup has been satisfactorily completed. The control system is complete and pre-functionally tested 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.

* + - * 1. Test Equipment: Refer to Section 01 9113, Part 2 for test equipment requirements.
				2. Problem Solving: The CxA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the GC, Subs and A/E.
			1. DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

Documentation: The CxA shall document the results of all functional tests using the specific procedural forms developed for that purpose. Prior to testing, these forms are provided to the PM for review and approval and to the Subs for review.

Non-Conformance

The CxA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the PM on the CxA’s standard issues tracking form.

Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases the deficiency and resolution will be documented on the procedure form.

Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CxA will not be pressured into overlooking deficient work, loosening acceptance criteria, or combining CxA functional testing with the contractor QA checkout procedures to satisfy scheduling or cost.

A complete round of tests will be performed, with results and deficiencies reported to the Subs and the PM. The responsible Subs will then have an opportunity to correct the deficiencies and schedule re-testing. Re-testing of up to 10% of the total number of executed tests will be provided by the CxA at no additional charge. Costs of additional re-testing will be as described in the next section.

When there is no dispute on the deficiency and the Sub accepts responsibility to correct it:

The CxA documents the deficiency and the Sub’s response with intentions and they go on to another test or sequence. The Sub corrects the deficiency and notifies the CxA that the system is ready to be retested.

The CxA reschedules the test and the test is repeated.

If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:

The deficiency shall be documented on the non-compliance form with the Sub’s response and a copy given to the PM and to the Sub representative assumed to be responsible.

Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the Project Manager.

The CxA documents the resolution process.

Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs the statement of correction on the non-compliance form and provides it to the CxA. The CxA reschedules the test and the test is repeated until satisfactory performance is achieved.

Cost of Retesting

The cost to retest a prefunctional or functional test beyond 10% of the total number of tests will be back-charged to the responsible Sub.

For a deficiency identified, not related to any prefunctional checklist or start-up fault, the following shall apply: The CxA and PM will direct the retesting of the equipment once at no “charge” to the GC for their time. However, the CxA’s time for a second test will be charged to the GC, who may choose to recover costs from the responsible Sub.

The time for the CxA to execute any re-testing required because a specific prefunctional checklist or start-up test item, reported to have been successfully completed, but determined during functional testing to be faulty, will be back-charged to the GC, who may choose to recover costs from the party responsible for executing the faulty prefunctional test.

Refer to the sampling section of Section 01 9113, Part 3.05 for requirements for testing and retesting identical equipment.

The Contractor shall respond in writing to the CxA and PM the status of each apparent outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.

Any required re-testing shall not be considered a justified reason for a claim of delay or for a time extension by the prime contractor.

Approval: The CxA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CxA and by the CM, if necessary. The CxA recommends acceptance of each test to the CM using a standard form.

* + - 1. REPORTS

Operation and Maintenance Manuals

The specific content and format requirements for the standard O&M manuals are detailed in 01 77 00 Closeout Procedures with specific section requirements in each discipline’s divisions .

CxA Review and Approval: Prior to substantial completion, the CxA shall review the O&M manuals, documentation and redline as-builds for systems that were commissioned to verify compliance with the specifications. The CxA will communicate deficiencies in the manuals to the PM or A/E, as requested. Upon a successful review of the corrections, the CxA recommends approval and acceptance of these sections of the O&M manuals to the PM. The CxA also reviews each equipment warranty and verifies that all requirements to keep the warranty valid are clearly stated. This work does not supersede the A/E’s review of the O&M manuals according to the A/E’s contract.

Final Commissioning Report

The final commissioning report shall include an executive summary, list of participants and roles, brief building description, overview of commissioning and testing scope and a general description of testing and verification methods. For each piece of commissioned equipment, the report should contain the disposition of the commissioning authority regarding the adequacy of the equipment, documentation and training meeting the contract documents in the following areas:

Equipment meeting the equipment specifications

Equipment installation

Functional performance and efficiency

Equipment documentation and design intent

Operator training.

All outstanding non-compliance items shall be specifically listed. Recommendations for improvement to equipment or operations, future actions, commissioning process changes, etc. shall also be listed. Each non-compliance issue shall be referenced to the specific functional test, inspection, trend log, etc. where the deficiency is documented.

The functional performance and efficiency section for each piece of equipment shall include a brief description of the verification method used (manual testing, BAS trend logs, data loggers, etc.) and include observations and conclusions from the testing.

Systems Manual **[May not be necessary for smaller projects – definitely do want this for new buildings]**

The CxA will provide a Systems Manual in addition to the O&M Manuals submitted by the Contractor. The Systems Manual generally focuses on operating, rather than maintaining the equipment, particularly the interactions between equipment.

The Systems Manual shall include the following for each commissioned system:

Final version of the Basis of Design

gle line diagrams

As-built sequences of operations, control drawings and original setpoints

Operating instructions for integrated building systems

Recommended schedule of maintenance requirements and frequency, if not already included in the project O&M manuals

Recommended schedule for calibrating sensors and actuators

* + - 1. TRAINING OF OWNER PERSONNEL

The GC shall be responsible for training coordination and scheduling and ultimately for ensuring that training is completed.

The CxA shall be responsible for monitoring and approving the content and adequacy of the training of Owner personnel for commissioned equipment, as called for in the contract documents.

The contractor will provide training for commissioned systems and equipment that covers the following topics:

General purpose of the system (design intent)

Use of the O&M manuals

Review of control drawings and schematics

Startup, normal operation, shutdown, unoccupied operation, seasonal changeover, manual operation, controls set-up and programming, troubleshooting, and alarms.

Interactions with other systems

Adjustments and optimizing methods for energy conservation

Relevant health and safety issues

Special maintenance and replacement sources

Tenant interaction issues

Discussion of environmentally responsive features of the system

In addition to these general requirements, specific training requirements (duration, topics, etc…) of Owner personnel by Subs and vendors is specified in various equipment sections in discipline’s Division specifications and in 01 79 00 Demonstration and Training specification.

Each Sub and vendor responsible for training will submit a written training plan to the CxA for review and approval prior to training. The plan will cover the following elements:

Equipment (included in training)

Intended audience

Location of training

Objectives

Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)

Subjects covered (description, duration of discussion, special methods, etc.)

Duration of training on each subject

Instructor for each subject

* + - 1. DEFFERRED TESTING

Unforeseen Deferred Tests: If any check or test cannot be completed due to the building structure, required occupancy condition, or other deficiency, execution of checklists and functional testing may be delayed upon approval of the PM. These tests will be conducted as soon as possible. Services of necessary parties will be negotiated.

* + - 1. WRITTEN WORK PRODUCT

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:

|  |  |
| --- | --- |
| **Product** | **Developed by** |
| Equipment documentation submittals | Subs |
| Sequence clarifications | Subs and A/E as needed |
| Pre-functional checklists  | CxA |
| Start-up and initial checkout plan | Subs w/ assistance from CxA |
| Pre-functional checklists filled out | Subs |
| Start-up and initial checkout forms filled out | Subs |
| Final TAB report | TAB |
| Issues log (deficiencies)  | CxA |
| Functional test forms | CxA and Subs |
| Filled out functional tests | CxA and Subs |
| Training plans and records | Subs |
| O&M manuals | Subs |
| Final Commissioning Report | CxA |

* + - * 1. END OF SECTION