

SECTION 019100 GENERAL COMMISSIONING REQUIREMENTS – LEED V4 BD+C

PART 1 - GENERAL

1.1 SUMMARY

- A. A Commissioning Agent (CxA), NORESKO, LLC., has been contracted by the owner to provide Commissioning (Cx) services for this project.
- B. The intent of this Specification is to:
 - 1. Familiarize the contractor with the Cx process and differences between a commissioned and “non-commissioned” project.
 - 2. Specify what labor / tasks are required by the contractor (and subcontractors) to support the commissioning effort, so the contractor (and subcontractors) can properly estimate the costs for this work. This specification should not be treated as an isolated document and must be read in conjunction with other related specifications as identified in section 1.4 of this specification.

1.2 DESCRIPTION

- A. Commissioning: Commissioning is a systematic process of ensuring that the building systems, including the mechanical, electrical, and plumbing systems, have been installed in the prescribed manner, are functionally checked and capable of being operated and maintained to perform with the design intent and have documentation to support proper installation and operation. The Commissioning Agent (CxA) shall provide the Owner with an unbiased, objective view of the system’s installation, operation and performance. This process does not eliminate or reduce the responsibility of each system designer to provide a complete design or installing subcontractors to provide a finished product. Commissioning is intended to enhance the quality of each system installation, startup and transfer to beneficial use by the Owner.
- B. 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 design, contract specification, manufacturer’s recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
 - 2. Verify and document proper performance of equipment and systems.
 - 3. Verify that Operation & Maintenance documentation is complete and transferred to Owner.
 - 4. Verify that the Owner’s operating personnel are adequately trained.
 - 5. Verify a contract is in place for a post occupancy review with O&M staff within 10 months after Substantial Completion.
- C. The Commissioning process shall be a team effort and encompass, as well as coordinate, the traditionally separate functions of system documentation, system installation,

equipment startup, control system calibration, testing, balancing and verification and performance checkouts.

- D. The CxA will work closely with the construction team, cooperating on and coordinating all Cx activities with the CM/Owner's representative, Trade Contractors, subcontractors, manufacturers and equipment suppliers.
- E. The Cx process shall not reduce the responsibility of the construction management group (CM/GC) to comply with the Contract Documents.

1.3 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, including 'LEED Requirement' apply to this Section.

1.4 RELATED SPECIFICATION SECTIONS INCLUDE

- A. Division 22: Plumbing specifications
- B. Division 23: HVAC specifications
- C. Division 26: Electrical Specifications

1.5 DEFINITIONS

- A. The following is a list of definitions utilized with this specification. Other definitions outlined in the General Conditions, Supplementary Conditions, Technical Specifications or other Contract Documents shall remain in effect.
 - 1. Acceptance Phase: Phase of construction after installation completion, startup and initial checkout when functional performance tests, operation and maintenance documentation review and training occur.
 - 2. 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.
 - 3. Architect/Engineer (A/E): The consultants who comprise the design team, generally the Architect, the HVAC Mechanical Engineer, the Plumbing Engineer and the Electrical Engineer.
 - 4. Basis of Design (BOD): A document that records the concepts, calculations, decisions and product selections used to meet the Owner's Project Requirements and to satisfy applicable regulatory requirements, standards and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process. The Designer of Record produces this document.
 - 5. Check Sheets: The step by step process that must be executed to fulfill the test requirements. The CxA shall develop the check sheets.

6. Commissioning Agent (CxA): The Commissioning Agent is an independent authority, not otherwise associated with the A/E team members, the CM or Trade Contractor. The CxA directs and coordinates day to day commissioning activities. The CxA does not take an project oversight role.
7. Commissioning Plan (CxP): An overall plan developed by the CxA before or after bidding that provides the structure, schedule and coordination planning for the Cx process.
8. Construction Manager (CM): The Construction Manager or their authorized representative appointed by the owner.
9. Pre-functional/ Installation Checklists (PCs): A list of items to inspect and elementary component tests to conduct to verify proper installation of equipment, provided by the CxA to the Subcontractors. Installation checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension correct, oil levels, labels affixed, gages in place, sensors calibrated, etc.). The word installation refers to pre functional testing. Installation checklists augment and are combined with the manufacturer's startup checklist.
10. Contract Documents: The documents binding all concerned involved in the construction of this Project (Drawings, Specifications, Bulletins, Change Orders, Amendments, other Contracts, Commissioning plans, etc.) as defined in the General Conditions of the Contract.
11. Control System: The central building management control system. (BAS or BMS system)
12. Data Logging: Monitoring flows, currents, status, pressures, etc. of equipment, using standalone data loggers separate from the control system.
13. Design Intent (DI): An explanation of the ideas, concepts and criteria that are considered to be very important to the Owner. It is initially the outcome of the programming and conceptual design phases. The design intent is established through the OPR and BOD documents.
14. Functional Performance Tests (FPTs): 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 is not functional testing, in the commissioning sense of the world.** The Commissioning Authority develops the functional test procedures in a sequential written form. The FPTs are generally developed from the approved sequence of operation and control logic in conformance to owner's project requirement and contract/design documents.

CxA coordinates, oversees, witnesses and documents the actual testing, which is usually performed by the installing Contractor or vendor. Function tests are performed after installation checklists and startup are complete.

15. Indirect Indicators: Indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100% closed.
16. Installing Contractor / Subcontractor: Contractor / Subcontractor who installs specific equipment and / or systems.
17. Issue: A condition in the installation or function of a component, piece of equipment or system that is not in compliance or conformance with the Contract Documents.
18. Issues Database: A formal and ongoing record of problems, deficiencies or concerns – and their resolution – that have been raised by members of the Commissioning Team during the course of commissioning. ‘Issues database’ is the primary tracking tool to address all commissioning issues by the concerned parties. All issues must be addressed / closed by the concerned parties before close-out.
19. Manual Test: A test using handheld instruments, immediate control system readouts or direct observation to verify performance (as opposed to analyzing monitored data taken over time to make the “observation”).
20. Master Equipment List (MEL): A complete listing of all commissioned building equipment, including detail such as make, model, etc., that is taken from submittals and is the basis from which check sheets will be generated.
21. Monitoring: The recording of parameters (flow, current, status, pressure, etc.) of equipment operation using data loggers or the trending capabilities of control systems.
22. Overwritten 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 to verify economizer operation). See also “Simulated Signal”.
23. Owner: Owner
24. Owner Contracted Tests: Tests paid for by the Owner outside of the CM’s Contract and for which the CxA does not provide oversight. These tests will not be repeated during functional tests if properly documented.
25. Owner’s Project Requirements (OPR): The Owner’s Project Requirements is the documentation of the primary thought processes and assumptions behind design decisions that were made to develop the Basis of Design (BOD and meet the design intent. The OPR describes the systems, components, conditions and methods chosen to meet the intent. Some reiterating of the design intent may be included.
26. Phased Commissioning: For projects that are anticipated to be completed in phases, commissioning that is completed in stages due to the size of the structure or other scheduling issues to minimize total construction time.

27. Sampling: Functional testing for a percent / fraction of the total number of identical or near identical pieces of equipment.
28. Seasonal Performance Tests: Functional tests that are deferred until or performed again when the system(s) will experience climate conditions closer to their design conditions.
29. Startup: The initial starting or activating of equipment, including executing construction checklists.
30. Subcontractors: The subcontractors that provide building components and systems under the General Construction Contractor.
31. Test Requirements: Requirements specifying what modes and functions, etc. shall be tested on any given piece of equipment or any given system (integrated and/or stand-alone). The test requirements are not the detailed test procedures. The test requirements for each system are specified in the respective section of the Contract Documents.
32. Testing, Adjust, Balance (TAB): Primary work is setting up the system flows and pressures as specified whereas functional testing is verifying that which has already been set up.
33. Trending: Monitoring using the building control system.
34. Vendor: Supplier of equipment.

1.6 REFERENCES

- A. General: Comply with the applicable provisions and recommendations of references, except as modified by governing codes and by the Contract Documents. Where a recommendation or suggestion occurs in the references, such recommendation or suggestion shall be considered mandatory. In the event of conflict between references, this specification or within themselves, the more stringent standard or requirement shall govern.
 1. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE): "ASHRAE Guideline 1.1-2019 ASHRAE Guideline HVAC&R Technical Requirements for The Commissioning Process
 2. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE): "ASHRAE Guideline 0-2019 ASHRAE Guideline 'The Commissioning Process'".

1.7 COMMISSIONING TEAM

- A. Commissioning Team: The members of the commissioning team consist of the CxA, USER/Owner, CM, the Architect and MEP Engineers, the Mechanical Trade Contractor, the Electrical Trade Contractor, the TAB representative (if independently retained), the Temperature Controls Contractor, as well as any other installing subcontractors or suppliers of equipment. The Owner's building or plant operator / engineer shall also be a member of the commissioning team.

- B. Members Appointed by CM: Individuals, each having authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated actions. The commissioning team may consist of, but not be limited to, representatives of each Contractor, including Project superintendent and subcontractors, installers, suppliers and specialists deemed appropriate by the CxA.
- C. Members Appointed by Owner:
 - 1. Commissioning Agent (CxA): The designated person, company or entity that plans, schedules and coordinates the commissioning team to implement the commissioning process. Owner will engage the CxA under a separate contract.
 - 2. Construction Manager (CM)
 - 3. Representatives of the facility user and operation and maintenance personnel.
 - 4. Architect and engineering design professionals.

1.8 OWNER'S RESPONSIBILITIES

- A. Provide the OPR & BOD documentation to the CxA and design team members for use in developing the commissioning plan; systems manual; operation and maintenance training plan; and testing plans and checklists.
- B. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities including, but not limited to, the following:
 - 1. Coordination meetings.
 - 2. Training in operation and maintenance of systems, subsystems, and equipment.
 - 3. Testing meetings.
 - 4. Demonstration of operation of systems, subsystems, and equipment.
- C. Provide the approved Contract Documents to the CxA and CM for use in developing the commissioning plan, systems manual, and operation and maintenance training plan.

1.9 CONSTRUCTION MANAGER'S (CM) RESPONSIBILITIES

- A. Provide utility services and any consumable required for the commissioning process.
- B. The CM shall assign representatives with expertise and authority to act on behalf of the CM and schedule them to participate in and perform commissioning team activities including, but not limited to, the following:
 - 1. Participate in design and construction phase coordination meetings.
 - 2. Insert Cx requirements into the master schedule.
 - 3. Participate in maintenance orientation and inspection.
 - 4. Participate in operation and maintenance training sessions.

5. Participate in final review at acceptance meeting.
6. Certify that Work is complete and systems are operational according to the Contract Documents, including calibration of instrumentation and controls. Notify the CxA when issues have been resolved.
7. Schedule testing, training, and provide a minimum of 48 hours notice to CxA for witnessing the testing.
8. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
9. Review and approve final commissioning documentation.
10. For enhanced commissioning, forward submittals to CxA for comment.

1.10 SUB CONTRACTOR'S RESPONSIBILITIES

- A. Subcontractors shall assign representatives with expertise and authority to act on behalf of subcontractors and schedule them to participate in and perform commissioning team activities including, but not limited to, the following:
 1. Participate in construction phase coordination meetings.
 2. Demonstrate all sequences to CxA.
 3. Participate in maintenance orientation and inspection.
 4. Participate in procedures meeting for testing.
 5. Execute Installation check sheets.
 6. Support functional testing with qualified technicians.
 7. Respond to Cx Issues Database within seven days of publication of issue.
 8. Participate in final review at acceptance meeting.
 9. Provide schedule for operation and maintenance data submittals, equipment startup, and testing to CxA for incorporation into the commissioning plan. Update schedule on a weekly basis throughout the construction period.
 10. Provide information to the CxA for developing construction phase commissioning plan.
 11. Co-ordinate / Conduct training sessions for Owner's operation and maintenance personnel.
 12. Provide updated Project Record Documents to the CxA on a daily / weekly basis.
 13. Gather and submit operation and maintenance data for systems, subsystems and equipment to the CxA 45 days after acceptance.

14. Provide technicians who are familiar with the construction and operation of installed systems and who shall develop specific test procedures and participate in testing of installed systems, subsystems and equipment.

1.11 COMMISSIONING AGENT'S (CxA) RESPONSIBILITIES

A. The functions and responsibility of the CxA shall include:

1. Organization and leadership of the Commissioning team with primary responsibility to inform the Owner and CM on the status, integration, and performance of systems within the facility.
2. Preparation of construction-phase commissioning plan and collaboration with CM and appropriate subcontractors and suppliers to develop testing and inspection procedures including design changes and scheduled commissioning activities coordinated with overall Project schedule.
3. Scheduling: The CxA shall work with the CM according to established protocols to schedule the commissioning activities. The CxA shall provide INPUTS to the CM for scheduling commissioning activities. The CM shall integrate all commissioning activities into the master schedule. All parties shall address scheduling problems and make necessary notifications in a timely manner to expedite the commissioning process.
4. Identification of commissioning team member responsibilities by name, firm and trade specialty for performance of each commissioning task.
5. Convene commissioning team meetings for the purpose of coordination, communication and conflict resolution; discuss progress of commissioning processes. Responsibilities include arranging for facilities, preparing agenda and attendance lists and notifying participants. The CxA shall prepare and distribute minutes to commissioning team members and attendees.
6. At the beginning of the construction phase, conduct an initial construction phase coordination meeting for the purpose of reviewing the commissioning activities and establishing tentative schedules for operation and maintenance submittals; operation and maintenance training sessions; testing, adjusting and balancing work; and Project completion.
7. Observe and inspect construction and report progress and deficiencies. In addition to compliance with the OPR, BOD and Contract Documents, inspect systems and equipment installation for adequate accessibility for maintenance and component replacement or repair.
8. Observation of Tests: CxA shall prepare, schedule (with the CM), coordinate, direct, witness and document Project specific tests, inspections, checkout and startup procedures (performed by the contractors) as required to ensure equipment and system installation, operation and performance meets the design intent. The CxA shall provide technical inputs to oversee and verify the correction of open issues found during the commissioning process.
9. Compile test data, inspection reports and certificates and include them in the commissioning report.

10. Acceptance: The CxA shall recommend acceptance to the Owner for each component and system for start of the warranty period.
 11. Review Project Record Documents for accuracy. Request revisions from CM to achieve accuracy.
 12. Review and comment on operation and maintenance documentation and systems manual outline for compliance with the OPR, BOD and Contract Documents.
 13. Review subcontractor submitted O&M & training documentation.
 14. Prepare commissioning reports.
 15. Assembly of the final commissioning documentation.
 16. For enhanced commissioning, review and comment on submittals from CM for compliance with the OPR, BOD, Contract Documents and construction phase commissioning plan. Review and comment on performance expectations of systems and equipment and interfaces between systems relating to the OPR and BOD.
- B. The CxA is referred to as an independent contractor in this Section and shall work under a separate contract directly for the Owner. The CxA shall not be financially associated with any of the work of the contractors or subcontractors on this project to avoid potential conflicts of interest.

1.12 COMMISSIONING DOCUMENTATION (the definitions are already covered under 1.5)

- A. Owner's Project Requirements.
- B. Basis of Design (BOD)
- C. Commissioning Plan: The commissioning plan is a living document that will evolve over the course of the project and ultimately include,:
 1. Description of the organization, layout and content of commissioning documentation and a detailed description of documents to be provided along with identification of responsible parties.
 2. Identification of systems and equipment to be commissioned.
 3. Description of schedules for testing procedures along with identification of parties involved in performing and verifying tests.
 4. Identification of items that must be completed before the next operation can proceed.
 5. Description of responsibilities of commissioning team members.
 6. Description of observations to be made.
 7. Schedule for commissioning activities

D. Pre-functional / Installation Checks (PC):

E. Functional Performance Tests (FPT): The end goal is that all associated equipment and components are verified simultaneously to ensure that all elements operate as per the contract documents. Each checklist, regardless of system, subsystem or equipment being tested, shall include, but not limited to, the following:

1. Name and tag of tested item.
2. Date of test.
3. Indication of whether the record is for a first test or retest following correction of a problem or issue.
4. Dated signatures of the person performing test and of the witness if applicable.
5. Deficiencies.
6. Issues, if any, generated as the result of test in the note section

F. Test and Inspection Reports: CxA shall record test data, observations and measurements on test checklists.

G. Issues Database: CxA shall prepare and maintain an issues database that describes design, installation and performance issues that are at variance with the OPR, BOD and Contract Documents. Identify and track issues as they are encountered, documenting the status of unresolved and resolved issues.

1. Documenting Issue Resolution:

- a. Log date correction is completed or the issue is resolved.
- b. Describe corrective action or resolution taken. Include description of diagnostic steps taken to determine root cause of the issue if any.
- c. Identify changes to the Owner's Project Requirements, Basis of Design, or Contract Documents that may require action.
- d. State that correction was completed and system, subsystem and equipment is ready for retest if applicable.
- e. Identify person(s) who corrected or resolved the issue.
- f. Identify person(s) documenting the issue resolution.

H. Commissioning Report: CxA shall document results of the commissioning process including unresolved issues and performance of systems, subsystems and equipment. The commissioning report shall indicate whether systems, subsystems and equipment have been completed and are performing according to the Owner's Project Requirements, Basis of Design and Contract Documents. The commissioning report shall include the following:

1. Owner's Project Requirements and Basis of Design documentation.
2. Commissioning plan.
3. Testing plans and reports.
4. Issues database.
5. Completed functional check sheets.
6. Listing of any seasonal test(s) remaining and a schedule for their completion.

I. Recommissioning Manual : CxA shall gather required information and compile a recommissioning manual.

J. Systems Manual : CxA shall gather required information and compile a systems manual. Systems manual shall include the following:

1.13 SUBMITTALS

- A. Commissioning Plans: Submit to Owner and Architect
- B. Testing: Submit to Owner and Architect
 1. Functional Checklists and Report Forms: CxA shall submit Prefunctional and functional test procedures to CM, A/E for review, comment, and distribution.
 2. Test and Inspection Reports: Submit for Owner and Architect's information. CxA shall submit test and inspection reports.
- C. Corrective Action Documents: CxA shall submit corrective action documents in the form of 'Issues Log'

1.14 SYSTEMS TO BE COMMISSIONED

- A. All parties associated with the design, installation and / or testing of these systems shall comply with commissioning requirements specified in this section, in the individual Division commissioning sections and detailed in the Commissioning Plan.
- B. Systems to be commissioned shall include:
 - HVAC systems
 - BAS Controls
 - System Testing and Balancing (witness, review)
 - Electrical distribution (normal, emergency)
 - Lighting and controls

- Plumbing System (Domestic Hot Water, Booster Pump)
- Fire Protection
- Fire Alarm System

1.15 COORDINATION

- A. The Owner/CM will furnish copies of all construction documents, addenda, change orders and appropriate approved submittals and shop drawings to the CxA.
- B. The CxA shall coordinate directly with the Owner / CM on the project specific to their responsibilities and contractual obligations. If the contractor is a subcontractor to another contractor, the CxA shall disseminate written information to all responsible parties relative to the nature and extent of the communication.
- C. The CxA is primarily responsible to the Owner, and therefore shall regularly apprise the Owner of progress, pending problems and / or disputes, as well as provide regular status reports on progress with each system.
- D. The CxA shall coordinate the schedule of commissioning activities with the construction schedule. It is possible that some procedures will be completed before the entire mechanical or electrical system is completed.

1.16 SCHEDULE

- A. Commissioning of systems shall proceed per the criteria established with activities to be performed on a timely basis. The CxA shall be available with a 48 hour notice to respond promptly and avoid construction delays.
- B. Startup and testing of systems may proceed prior to final completion of systems to expedite progress. However, the CxA shall not schedule testing and checkout services that are the primary responsibility of the contractor / vendor in advance of their testing and checkout.
- C. Open issues observed shall be addressed immediately, responsible parties notified, and corrective actions coordinated in a timely manner.
- D. Construction schedules and scheduling are the responsibility of the CM. The CxA shall provide commissioning scheduling information to the Owner's Representative and CM for review and planning activities.

1.17 OTHER REQUIREMENTS

- A. Commissioning requires support from the CM, GCC, Trade Contractors and subcontractors. The commissioning process does not relieve any contractors from their obligations to complete all portions of work in a satisfactory manner.
- B. Commissioning requirements in this section should not be confused with "commissioning" requirements at the end of various technical specification sections. Those requirements that are at the end of various technical specification sections are part

of the quality control procedures and are to be completed by the respective contractor before the commissioning process begins.

- C. Refer to the Commissioning plan submitted by the CxA for a detailed description of all commissioning requirements and responsibilities for all involved parties including: Owner, Owner's Representative, Architect, Design Engineer, CM, GCC, Trade Contractors, and Subcontractors.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All industry standard test equipment required for performing the specified tests shall be provided by the appropriate party responsible for the testing. Any proprietary vendor specific test equipment shall be provided by that vendor or manufacturer.
- B. 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 Trade Contractor and left on site, except for standalone data logging equipment that may be used by the CxA.
- C. If data logging equipment is required, the loggers and the necessary software shall be provided by the CxA but not become the property of the Owner.
- D. Any portable or handheld setup / calibration devices required to initialize the control system shall be made available by the control vendor (at no additional cost) to the CxA.
- E. The instrumentation used in the commissioning process shall comply with the following:
 - 1. Be of sufficient quality and accuracy to test and / or measure system performance within the tolerances required.
 - 2. Be calibrated at the manufacturer's recommended intervals with calibration tags permanently affixed to the instrument.
 - 3. Be maintained in good repair and operating condition throughout use duration on this project.
 - 4. Be immediately recalibrated or repaired if dropped and / or damaged in any way during use on this project.

PART 3 - EXECUTION

3.1 COMMISSIONING PLAN AND SCHEDULE

- A. The CxA shall develop and submit a schedule identifying the commissioned system and commissioning process which is integrated by the CM with the construction schedule. The required work by all team members (CxA, Trade Contractors and the Owner) shall be included. Overlay with the construction schedule, and include time for test and balance, Installation checkouts, as well as Functional testing.

- B. Commissioning Plan: The Commissioning Plan provides guidance in the execution of the Commissioning process. Just after the initial Commissioning kickoff meeting, the CxA will update the initial plan, which is then considered the “final” plan (though it will be a living document that may continue to evolve and expand as the project progresses). The Specifications will take precedence over the Commissioning Plan.

3.2 COMMISSIONING PROCESS

- A. Commissioning Process: The following provides an overview of the Commissioning tasks during design and construction and the general order in which they occur.

1. Design Phase

- a. Commissioning during the design phase begins with a Commissioning kick-off meeting, chaired by the CxA, which the Commissioning process is set forth.
- b. Commissioning shall include the design review (usually 75% CD and back check of 100% CD), provide comments from commissioning perspective.

2. Construction Phase

- a. Commissioning during construction begins with a Commissioning orientation meeting, conducted by the CxA, where the Commissioning process is reviewed with the other Commissioning team members.
- b. Additional meetings may be required throughout construction, scheduled by the CxA with necessary parties attending, to plan, scope, coordinate and schedule future activities and resolve open issues.
- c. Equipment documentation for commissioned systems/equipment is submitted to the CxA for review, concurrent with normal submittals, including detailed startup procedures.
- d. The CxA works with the CM, Trade Contractors and subcontractors in developing PC/FPT documentation formats.
- e. In general, the checkout and performance verification proceeds from simple to complex; from component level to equipment to systems and intersystem levels with Installation checklists being completed before Functional Performance Checklists.
- f. The CxA develops specific equipment installation check sheets. The Subs, with guidance from the CxA, execute and document the Installation checklists and perform startup and initial checkout. The CxA documents that the checklists and startup were completed according to the approved plans. This may include the CxA witnessing portions of the startup of selected equipment and spot checking the Installation check sheets.
- g. The CxA develops specific equipment and system Functional check sheets. The Subs receive copies of the procedures. 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.

- h. The Functional and/or system performance check sheets are executed by the subs, witnessed by the CxA.
- i. Items of non-compliance in material, installation or setup are corrected and the system rechecked not to exceed one additional time.
- j. The CxA reviews the Operation & Maintenance documentation for completeness.
- k. Commissioning is completed before Substantial Completion.
- l. The CxA reviews the training documentation. The training schedules are provided by the Subs and CxA verifies that training was completed.
- m. Deferred testing / checkouts are conducted, as specified or required.

3.3 INSTALLATION / FUNCTIONAL PERFORMANCE

- A. Personnel experienced in the technical aspects of each system to be commissioned shall develop and document the commissioning procedure to be used. Include a performance checklist and performance checkout data sheets for each system based on actual system configuration. These procedures shall be reviewed by the Owner for technical depth, clarity of documentation and completeness. Special emphasis shall be placed on checkout procedures that shall conclusively determine actual system performance and compliance with the design intent.
- B. The majority of mechanical equipment requires safety devices to stop and / or prevent equipment operation unless minimum safety standards or conditions are met. These may include adequate oil pressure, proof-of-flow, non-freezing conditions, maximum static pressure, maximum head pressure, etc. The party responsible for checkout procedures shall observe the actual performance of safety shutoffs in a real or closely simulated condition of failure.
- C. Systems may include safety devices and components that control a variety of equipment operating as a system. Interlocks may be hard-wired or operate from software. The party responsible for commissioning checkout procedures shall verify operation of these interlocks.
- D. The CxA shall determine the acceptance procedures for each system within disciplines. The acceptance procedures shall incorporate the commissioning standards and successful testing results as referred to throughout specifications.

As a guidance for HVAC system acceptance, the following should be considered

- 1. The temperature control system shall have all I/O points individually verified for proper function, calibration, and operation. The CxA shall review proposed testing procedures and report formats, and observe sufficient field testing to confirm that all I/O points have been properly tested.
- 2. All control sequence of operation strategies, alarm generation and reporting shall also be reviewed and proper operation verified by the CM and Trade Contractors with oversight by the CxA.

3. The central work station graphics, point assignments, alarm messages, and logging functions shall be verified.
- E. The appropriate contractor and vendor(s) shall be informed of what tests are to be performed and the expected results. Whereas some test results and interpretations may not become evident until the actual tests are performed, all parties shall have a reasonable understanding of the requirements. The commissioning plan shall address those requirements and be distributed to all parties involved with that particular system.
- F. Acceptance procedures shall confirm the performance of systems to the extent of the design intent. When a system is recommended to be accepted, the Owner shall be assured that the system is complete, works as intended, is correctly documented, and operator training has been performed.

3.4 FUNCTIONAL PERFORMANCE TESTS – OBSERVATION / WITNESS

- A. The Functional Performance tests shall be performed by the contractors and vendors with oversight by the CxA. The CxA shall witness, verify and document these tests.
- B. Check sheets shall be completed comprehensively and to the extent necessary to enable the CxA to assure the Owner that the systems do perform per the owner's requirement.

3.5 SOFTWARE DOCUMENTATION REVIEW

- A. Review software documentation for all DDC control systems. This includes review of vendor documentation and specific software routines applied to this project. Discrepancies in sequences shall be reported and coordinated to provide the Owner with the most appropriate, simple and straightforward approach to software routines.

3.6 TESTING PREPARATION

- A. Prerequisites for Testing:
 1. Certify that commissioned systems, subsystems and equipment have been completed, calibrated and started; are operating according to the OPR, BOD and Contract Documents; and that Certificates of Readiness are signed and submitted.
 2. Certify that all relevant instrumentation and control systems have been completed and calibrated; are operating according to the OPR, BOD and Contract Documents; and that pretest set points have been recorded.
 3. Certify that testing, adjusting and balancing (TAB) procedures have been completed, and that TAB report have been submitted, discrepancies corrected and corrective work approved.
 4. Test systems and intersystem performance after approval of testing check sheets for systems, subsystems and equipment.
 5. Set systems, subsystems and equipment to operating mode to be tested (e.g., normal shut down, normal auto position, normal manual position, unoccupied cycle, emergency power and alarm conditions).
 6. Verify each mode of operation once it is operating in a steady state condition.

7. Inspect and verify the position of each device and interlock identified on checklists. Sign off each item as acceptable or failed. Repeat this test for each operating cycle that applies to system being tested.
 8. Check safety cutouts, alarms and interlocks with smoke control and life safety systems during each mode of operation when applicable.
 9. Annotate checklist or data sheet when a deficiency is observed.
 10. Verify equipment interface with monitoring and control system and the TAB
- B. Testing Instrumentation: Install measuring instruments and logging devices to record test data for the required test period. Instrumentation shall monitor and record full range of operating conditions and shall allow for calculation of total capacity of system for each mode of operation. For individual room cooling tests, Operational modes generally include the following:
1. Occupied and unoccupied.
 2. Warm up and cool down.
 3. Economizer cycle.

3.7 TESTING

- A. Test systems and intersystem performance as per the test procedures. Perform tests using design conditions whenever possible.
1. Simulate conditions by imposing an artificial load when it is not practical to test under design conditions and when written approval for simulated conditions is received from CxA. Before simulating conditions, calibrate testing instruments. Set and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
 2. Alter setpoints when simulating conditions is not practical and when written approval is received from CxA.
 3. If a test is failed for reason and retesting is required, the concerned agency (contractor, equipment manufacturer) shall provide the service on an agreed upon date at no cost to the owner.
 4. Alter sensor values with a signal generator when design or simulating conditions and altering set points are not practical. Do not use sensor to act as signal generator to simulate conditions or override values.

3.8 COST OF RETESTING

- A. The cost for the GC/trade contractor to retest a prefunctional or functional test, if they are responsible for the deficiency, shall be theirs.
- B. For a deficiency identified, not related to any prefunctional checklist or start-up fault, the following shall apply: The CxA will direct the retesting of the equipment once at no charge to the owner for their time. However, the CxA's time for a second retest will be charged to the Owner, who may choose to recover costs from the responsible GC/Sub-contractors.

- C. The time for the CxA to direct any retesting required because a specific prefunctional check-list or start-up test item, reported to have been successfully completed, but determined during functional testing to be faulty, will be charged to the owner, who may choose to recover costs from the party responsible for executing the faulty prefunctional test.
- D. 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 prime contractor or GC.

3.9 OPERATION & MAINTENANCE MANUALS

- 1. The CxA shall review the Operation & Maintenance manuals provided by Trade Contractors or subcontractors. The review process shall verify that Operation & Maintenance instructions meet specifications and are included for all equipment furnished by the Trade Contractor.
 - 2. Published literature shall be specifically oriented to the provided equipment, indicating required operation and maintenance procedures, parts lists, assembly / disassembly diagrams and related information.
 - 3. The Trade Contractor shall incorporate the standard technical literature into system specific formats for this facility as designed and as actually installed. The resulting Operation & Maintenance information shall be system specific, concise, to the point and tailored specifically to this facility. The CxA shall review and edit these documents as necessary for final corrections by the Trade Contractor.
- B. The Operation & Maintenance Manual review and coordination efforts shall be completed prior to Owner training sessions, as these documents are to be utilized in the training sessions.

3.10 CURRENT FACILITY REQUIREMENTS (CFR) AND OPERATION & MAINTENANCE (O&M) PLAN

- A. Per Contract Documents and as part of LEED v4 BD+C fundamental commissioning, the CxA shall prepare and deliver the documents that are required to operate the building . The contractors will confirm the proper documents are onsite and readily available. Typically, the manual includes the following:
- 1. As built sequences of operation for all equipment and control drawings.
 - 2. List of programmed equipment operation schedules and frequency for their review (e.g., seasonal).
 - 3. Setpoint for all HVAC equipment.
 - 4. Building operation schedules and frequency for their review.
 - 5. Lighting levels throughout the building.
 - 6. Minimum outside air requirements.
 - 7. Systems narrative describing the mechanical and electrical systems and equipment.
 - 8. Preventative maintenance plan for building equipment described in the systems narrative.

9. Cx program that includes periodic Cx requirements, ongoing Cx tasks, and continuous tasks for critical facilities

3.11 SYSTEMS MANUAL

- A. Per Contract Documents and as part of LEED v4 BD+C enhanced commissioning, the CxA shall prepare and deliver the documents that are required to periodically “tune up” building systems. The contractors will confirm the proper documents are onsite and readily available. Typically, the manual includes the following:
 1. As built sequences of operation for all equipment and control drawings.
 2. List of programmed operation schedules and frequency for their review.
 3. Engineering narratives for all energy and water saving methods and equipment (supplied by the Engineer of Record).
 4. Benchmarks for energy use tracking and guidelines for future additions. (Based on Energy Modeling Conducted)
 5. Narrative of seasonal operational issues, including seasonal startup and shutdown, manual and restart operation procedures, recommendations regarding seasonal operational issues that affect energy use.
 6. List of all user adjustable setpoints and reset schedules with a brief discussion of the purpose of each and the range of reasonable adjustments with energy implications.
 7. Recommendations for recalibration frequency for sensors and actuators.
 8. Recommendations for user adjustable setpoints and frequency of checking.
 9. Recommended frequency of Recommissioning.
 10. List of diagnostic tools and directions for use.

3.12 TRAINING

- A. The CM shall schedule and coordinate training sessions for the Owner’s staff for each system. Training shall be held per Contract Documents, along with the appropriate schematics, handouts and visual / audio training aids onsite with equipment.
- B. The appropriate installing Trade Contractor shall provide training on all the major systems per specifications, including peculiarities specific to this project.
- C. The equipment vendors shall provide training on the specifics of each major equipment item including philosophy, troubleshooting and repair techniques.
- D. The automatic control and fire alarm vendors shall provide training on the control system and fire alarm system per their specification section.
- E. For additional prescription pertinent to training, refer to other specific divisions for training requirements.

3.13 WARRANTY REVIEW / SEASONAL TESTING

- A. The CxA will return upon the start of the new season (cooling or heating) after project completion to conduct performance tests that could not be performed due to ambient conditions. The seasonal testing will only be performed if unsuitable loads / conditions were unavailable during the performance testing stages (in other words; the requirement for testing is warranted).
- B. If agreed upon by Owner, Seasonal Testing can also be used for the Warranty Review. During which the CxA will interview the occupants, maintenance staff, review the operation of the building, provide recommendations for installation and operational problems and document warranty and operational issues in the issues database.

3.14 EXCLUSIONS

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

END OF SECTION 019100