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12. Building Commissioning Guide

For all newly constructed nonresidential buildings, commissioning shall be included in the design and construction process of the project to verify that the building's energy systems and components meet the owner's or owner representative's project requirements. For buildings less than 10,000 square feet, only the Design Phase Design Review requirements (see Section 12.4) and Commissioning Measures Shown in the Construction Documents (see Section 12.5) shall be completed.

Note: For hotel/motel or high-rise residential buildings that are considered mixed-use, the occupancies designated as nonresidential shall comply with these commissioning requirements when applicable.

This chapter is organized as follows:

- 12.1 Introduction
- 12.2 Owner's or owner representative's project requirements
- 12.3 Basis of design
- 12.4 Design phase review
- 12.5 Commissioning measures shown in the construction documents
- 12.6 Commissioning plan
- 12.7 Functional performance testing
- 12.8 Documentation and training
- 12.9 Commissioning report
- 12.10 Commissioning Compliance Documents

12.1 Introduction

The purpose of this code is to improve public health, safety, and general welfare by enhancing the design and construction of buildings through the use of concepts that reduce negative and increase positive environmental impacts. Commissioning is a vital element in this effort.

The following acronyms will be used throughout this Chapter:

Acronyms

- BOD - Basis of Design
- Cx - Commissioning
- FPT - Functional Performance Test
- HVAC - Heating, Ventilating, and Air Conditioning
- O&M - Operations and Maintenance
- OPR - Owner's Project Requirements

Glossary

- **Acceptance Criteria** - The conditions that must be met for systems or equipment to meet defined expected outcomes.
- **Commissioning (Cx)** --Building commissioning as required in this code involves a quality assurance process that begins during design and continues to occupancy. Commissioning verifies that the new building and its systems are planned, designed, installed, tested, operated and maintained as the owner intended, and the building staff are prepared to operate and maintain its systems and equipment.
- **Commissioning Coordinator**-- The person who plans, schedules and coordinates the commissioning team to implement the commissioning process. This can be either a third-party commissioning provider or an experienced member of the design team or owner's staff.
- **Commissioning Process** – A quality-focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that all its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements.
- **Commissioning Team** - The key members of each party involved with the project designated to provide insight and carry out tasks necessary for a successful commissioning project. Team members may include the commissioning coordinator, owner or owner's representative, building staff, design professionals, contractors or manufacturer's representatives, and testing specialists.
- **Independent Third-Party Commissioning Professional (Authority/Agent/Provider/Lead)** – An entity contracted directly by the owner who is not responsible or affiliated with any other member of the design and construction team and who leads, plans, schedules, and coordinates the Commissioning Team to implement the Commissioning Process.
- **Operation and Maintenance (O&M) Manuals** - Documents that provide information necessary for operating and maintaining installed equipment and systems.
- **Owner** - The individual or entity holding title to the property on which the building is constructed.
- **Owner Representative** – An individual or entity assigned by the owner to act and sign on the owner's behalf.
- **Sequence of Operation** – A written description of the intended performance and operation of each control element and feature of the equipment and systems.
- **Scope of the Commissioning Requirements** - All building systems and components covered by §110.0, §120.0, §130.0, and §140.0 shall be included in the scope of the commissioning requirements, excluding covered processes.

12.1.1 Selecting Trained Personnel for Commissioning

It is essential that there is a single person designated to lead and manage the commissioning activities. In practice, this individual has been referenced by various identifiers such as commissioning authority, agent, provider, coordinator, and lead. In this manual, the term commissioning coordinator is used.

The commissioning coordinator shall manage and facilitate the commissioning process, including managing the development and implementation of the commissioning tasks and associated documentation. Trained personnel shall execute the tasks and may include appropriate members of the owner's staff, contractors, and design team, as well as independent commissioning professionals.

The designated commissioning coordinator may be an independent third-party commissioning professional, a project design team member (e.g. engineer or architect), an owner's engineer, contractor, or specialty sub-contractor. Methods of evaluating the designated commissioning coordinator and trained personnel include review of the following:

- Technical knowledge.
- Relevant experience.
- Potential conflict of interest.
- Professional certifications and training.
- Communication and organizational skills.
- Reference and sample work products.

12.2 Owner's Project Requirements (OPR)

§120.8(b)

The energy-related expectations and requirements of the building shall be documented before the design phase of the project. This documentation shall include the following:

1. Energy efficiency goals.
2. Ventilation requirements.
3. Project program, including facility functions and hours of operation, and need for after-hours operation.
4. Equipment and systems expectations.

12.2.1 Intent

The Owner's Project Requirements (OPR) documents the functional requirements of a project and expectations of the building use and operation as it relates to systems being commissioned. The document describes the physical and functional building characteristics desired by the owner and establishes performance and acceptance criteria. The OPR is most effective when developed during pre-design and used to develop the BOD during the design process. The level of detail and complexity of the OPR will vary according to building use, type and systems.

12.2.2 Compliance Method

Compliance is demonstrated by the owner or owner's representative developing and/or approving the OPR document before the design phase begins. At a minimum, the following components should be included in the OPR:

A. Energy Efficiency Goals – Establish goals and targets affecting energy efficiency which may include:

1. Overall energy efficiency (exceeding Title 24 by %).

2. Lighting system efficiency (exceeding Title 24 by %).
 3. HVAC equipment efficiency & characteristics.
 4. Any other measures affecting energy efficiency desired by the owner
 - a. Building orientation and siting
 - b. Daylighting
 - c. Facade, envelope and fenestration
 - d. Roof
 - e. Natural ventilation
 - f. Onsite renewable power generation and zero net energy use
 - g. Landscaping and shading
- B. Ventilation Requirements** - Describe indoor ventilation requirements including intended use and anticipated schedule for each program space.
- C. Project Program, including facility functions and hours of operation, and need for after-hours operation** – Describe primary purpose, program, and use of proposed project, such as:
1. Building size, number of stories, construction type, occupancy type, and number.
 2. Building program areas including intended use and anticipated occupancy schedules.
 3. Future expandability and flexibility of spaces.
 4. Quality and/or durability of materials and building lifespan desired.
 5. Budget or operational constraints.
 6. Applicable codes.
- D. Equipment and Systems Expectations** – For each system commissioned describe the following:
1. Level of quality, reliability, equipment type, automation, flexibility, maintenance and complexity desired.
 2. Specific efficiency targets, desired technologies, or preferred manufacturers for building systems.
 3. Degree of system integration, automation, and functionality for controls (i.e. load shedding, demand response, and energy management)
- E. Building Envelope Performance Expectations** – For each assembly that contains a special feature describe the following:
1. Assembly type, such as, floors, foundations, walls, ceilings, and roofs.
 2. Characteristic that merits special attention.
- F. Enforcement** - At their discretion, the building official confirms demonstrated compliance at *Plan Review* by either:
1. Receipt of a copy of the OPR document (optional).
 2. Receipt of a completed NRCC-CXR-01-E indicating the OPR was reviewed at the Design Review Kickoff.

12.3 Basis of Design (BOD)

§120.8(c)

A written explanation of how the design of the building systems meets the OPR shall be completed at the design phase of the building project, and updated as necessary during the design and construction phases. The Basis of Design (BOD) document shall cover the following systems and components:

1. HVAC systems and controls.
2. Indoor lighting system and controls.
3. Water heating systems and controls.
4. Any building envelope component considered in the OPR.

12.3.1 Intent

The BOD describes the building systems to be commissioned and outlines design assumptions not indicated in the design documents. The design team develops the BOD to describe how the building systems design meets the OPR, and why the systems were selected. The BOD is most effective when developed early in the project design and updated, when necessary, throughout the design process.

12.3.2 Compliance Method

Compliance requires the completion of the BOD document, which should include the following:

A. HVAC Systems and Controls

1. Provide narrative description of system – system type, location, control type, efficiency features, outdoor air ventilation strategy, indoor air quality features, environmental benefits, and other special features.
2. Describe reasons for system selection – why chosen system is better than alternatives, considering issues such as comfort, performance, efficiency, reliability, flexibility, simplicity, cost, owner preference, site constraints, climate, maintenance, and acoustics.
3. Provide design criteria including the following:
 - a. Load calculation method/software.
 - b. Summer outdoor design conditions, °F drybulb and °F wetbulb.
 - c. Winter outdoor design conditions, °F drybulb and °F wetbulb.
 - d. Indoor design conditions, °F drybulb cooling, %RH cooling; °F drybulb heating, % RH heating.
 - e. Applicable codes, guidelines, regulations and other references used.
 - f. Load calculation assumptions.
4. Sequence of Operations – operating schedules, setpoints (may refer to plans or specifications).
5. Describe how the system meets the OPR.

B. Indoor Lighting System and Controls

1. Provide narrative description of system – type of fixtures, lamps, ballasts, and controls.
2. Describe reason for system selection – why chosen system is better than alternatives, considering issues such as visual comfort, performance, efficiency, reliability, cost, flexibility, owner preference, color rendering, integration with daylighting, and ease of control.
3. Provide design criteria for each type of space including the following:
 - a. Applicable codes, guidelines, regulations and other references used.
 - b. Illumination design targets (footcandles) and lighting calculation assumptions.
4. Provide lighting power design targets for each type of space
 - a. Lighting power allowance and lighting power design target (watts/ft²).
5. Describe how system meets the OPR.

C. Water Heating Systems and Controls

1. Provide narrative description of system – system type, control type, location, efficiency features, environmental benefits, and other special features.
2. Describe reason for system selection – why chosen system is better than alternatives, considering issues such as performance, efficiency, reliability, space constraints, cost, utility company incentives, owner preference, and ease of maintenance
3. Water heating load calculations.
4. Describe how system meets the OPR.

D. Building Envelope Components

1. Provide narrative description of system – type, energy savings, and payback period.
2. Describe reason for system selection – why chosen system is better than alternatives, considering issues such as performance, efficiency, reliability, flexibility, simplicity, expandability, cost, payback period, utility company incentives, and owner preference.
3. Describe how system meets the OPR.

12.3.3 Enforcement

At their discretion, the building official confirms demonstrated compliance at *Plan Review* by either:

1. Receipt of a copy of the BOD document (optional).
2. Receipt of a completed NRCC-CXR-01-E indicating the BOD was reviewed at the Design Review Kickoff attesting that the BOD has been completed and meets the requirements of the OPR.

12.4 Design Phase Review

§120.8(d)

1. Design reviewer requirements are based on the project size and complexity of the mechanical systems, as follows:
 - a. For newly constructed buildings less than 10,000 square feet, design phase review may be completed by the design engineer.
 - b. Newly constructed buildings between 10,000 and 50,000 square feet, it may be completed by either an in-house engineer to the design firm but not associated with the building project, or a third party design engineer.
 - c. For newly constructed buildings larger than 50,000 square feet or buildings with complex mechanical systems, an independent review by a third party design engineer is required.
2. Design Review. During the schematic design phase of the building project, the owner or owner's representative, design team and design reviewer must meet to discuss the project scope, schedule and how the design reviewer will coordinate with the project team. The building owner or owner's representative shall include the Design Review Checklist in the Certificate of Compliance documentation (see §10-103).
3. Construction Documents Design Review. The design review compliance documents list the items that shall be checked by the design reviewer during the construction document review. The completed compliance documents shall be returned to the owner and design team for review and sign-off. The building owner or owner's representative shall include the design review compliance documents in the Certificate of Compliance documentation (see §10-103).

12.4.1 Intent

The intent of design phase review is to improve compliance with the Energy Standards, encourage adoption of best practices in design, and lead to designs that are constructible and maintainable.

12.4.2 Compliance Method

Compliance requires completion of the Design Review Kickoff and Construction Document checklists by the design reviewer. Requirements for the design reviewer are provided in §120.8(d)1. The following steps are required to complete this requirement:

A. Design Review Kickoff - Initial Schematic Review

1. An in-person meeting is held between the project owner (or owner's representative), design team representatives (including mechanical and electrical design engineers, project architect), commissioning coordinator, and design reviewer.
2. Meeting topics to be discussed include the following:
 - a. Discuss Project Coordination, including design reviewer involvement.
 - b. Identify Project Scheduling, including design review.
 - c. Review Project scope.
 - d. Review OPR and BOD.
 - e. Discuss Design Elements and Assumptions.

- f. Discuss HVAC System Selection.
- g. Identify Construction Documents Design Review checklists to be completed.
- h. Discuss Energy Efficiency Measures.
- i. Complete and Sign Certificate of Compliance – Cx Design Review Kickoff NRCC-CXR-01-E.

B. Construction Document Review

1. The design team provides the design reviewer with a set of drawing plans and specifications late in design as agreed upon in Design Review Kickoff meeting, typically around 90 percent construction document completion.
2. The Design reviewer provides a review of the construction documents:
 - a. NRCC-CXR-02-E. This compliance document is used as a checklist for all projects that require a Construction Documents Design Review.
 - b. NRCC-CXR-03-E. This compliance document is used as a supplement to the NRCC-CXR-02-E for simple mechanical systems.
 - c. NRCC-CXR-04-E. This compliance document is used as a supplement to the NRCC-CXR-02-E for complex mechanical systems.
3. Completed compliance documents are submitted to the design team and project owner for consideration.
4. The designer provides a response on the Construction Document compliance documents. The design reviewer is not required to provide a second review of the construction documents for compliance purposes.
5. Certification of Completion - The design reviewer, design engineer, and owner/owner's representative sign the Certificate of Compliance – Cx Design Review Signature Page, NRCC-CXR-05-E, indicating that the construction documents design review has been completed.

The commissioning coordinator who meets the requirements may also complete the construction documents design review.

12.4.3 Enforcement

Compliance is demonstrated by completion of the compliance documents NRCC-CXR-01-E through NRCC-CXR-04-E, as applicable, and signature page, NRCC-CXR-05-E.

12.5 Commissioning Measures

§120.8(e)

This section includes commissioning measures or requirements in the construction documents (plans and specifications) for newly constructed nonresidential buildings. Commissioning measures or requirements should be clear, detailed and complete to clarify the commissioning process. These requirements should include:

- The list of systems and assemblies commissioned.
- Testing scope.
- Roles and responsibilities of contractors.

- Requirements for meetings.
- Management of issues.
- The commissioning schedule.
- O&M manual development and training.
- Checklist and functional test compliance document development, execution and documentation.
- Roles of non-contractor parties (for information only).

12.5.1 Intent

Include commissioning measures or requirements in the construction documents (plans and specifications). Commissioning measures or requirements should be clear, detailed and complete to clarify the commissioning process.

12.5.2 Existing Law or Regulation

The Energy Standards require that specific functional test compliance documents (Certificate of Acceptance) be included in the construction documents. These functional test compliance documents are a subset of the broader commissioning requirements described in this chapter.

12.5.3 Compliance Method

Compliance is achieved by including commissioning requirements in the project plans and specifications. The commissioning specifications should include the following:

- A. Primary (and optionally all) commissioning requirements are included in the general specification division (typically Division 1) and clear cross references of all commissioning requirements to and from the general division are included to ensure all subcontractors are held to them.
- B. A list of the systems and assemblies covered by the commissioning requirements.
- C. Roles and responsibilities of all parties including:
 1. General contractor and subcontractors, vendors, and construction manager.
 2. Commissioning coordinator.
 3. Owner, facility staff.
 4. Architect and design engineers.
 5. Non-contractor parties (for information only to provide the contractor with context for their work).
 6. The individual who writes checklists and tests, reviews and approves functional test compliance documents, directs tests and executes tests, documents test results, and approves completed tests. These roles may vary by system or assembly.
- D. Meeting requirements.
- E. Commissioning schedule management procedures.
- F. Issue and non-compliance management procedures.

- G. Requirements for execution and documentation of installation, checkout, and start up, including control point-to-point checks and calibrations.
- H. Specific testing requirements by system, including:
 - 1. Monitoring and trending.
 - 2. Opposite season or deferred testing requirements, functions and modes to be tested.
 - 3. Conditions of test.
 - 4. Acceptance criteria and any allowed sampling.
 - 5. Details of the format and rigor of the functional test compliance documents required to document test execution.
 - 6. Example compliance documents (recommended).
- I. Submittal review requirements and approval process.
- J. Content, authority and approval process of the commissioning plan.
- K. Commissioning documentation and reporting requirements.
- L. Facility staff training requirements and verification procedures.
- M. O&M manual review and approval procedures.
- N. System's manual development and approval requirements and procedures.
- O. Definitions section.

12.5.4 Enforcement

At their discretion, the building official confirms demonstrated compliance at *Plan Review* by a receipt of a copy of the commissioning specifications.

12.6 Commissioning Plan

§120.8(f)

Prior to permit issuance, a commissioning plan shall be completed to document how the project will be commissioned and shall be started during the design phase of the building project. The Commissioning Plan shall include the following:

- A. General project information.
- B. Commissioning goals.
- C. Systems to be commissioned.
- D. Plans to test systems and components, which shall include:
 - 1. An explanation of the original design intent.
 - 2. Equipment and systems to be tested, including the extent of tests.
 - 3. Functions to be tested.
 - 4. Conditions under which the test shall be performed.
 - 5. Measureable criteria for acceptable performance.

6. Commissioning team information including roles.
7. Commissioning process activities, schedules and responsibilities. Plans for the completion of commissioning requirements listed in §120.8(g) through §120.8(i) shall be included.

12.6.1 Intent

The Commissioning Plan (Cx Plan) establishes the commissioning process guidelines for the project and commissioning team's level of effort. It identifies the required Cx activities to ensure that the OPR and the BOD are met. The Cx Plan also includes a commissioning schedule from design to occupancy.

12.6.2 Existing Law or Regulation

Review local county, city, or jurisdiction ordinances for any applicable commissioning planning requirements.

12.6.3 Compliance Method

Compliance is demonstrated by preparation of a project specific Cx Plan that includes the elements listed in the code section above. The following gives guidance for developing the components of the Commissioning Plan:

- A. General project information** - Provide project identifying information, including, but not limited to the following:
 1. Project name, owner, and location.
 2. Building type and area.
 3. Project Schedule.
 4. Contact information of individual/company providing the commissioning services.
- B. Commissioning Goals** – Document the commissioning goals, including, but not limited to:
 1. Meeting code requirements for commissioning.
 2. Meeting OPR and BOD requirements.
 3. Carrying out requirements for commissioning activities as specified in plans and specifications.
- C. Systems to be commissioned** – See BOD
 1. *An explanation of the original design intent* - Document the performance objectives and design intent for each system listed to be commissioned in a written narrative
 - a. Refer to the OPR and BOD documents.
 2. *Equipment and systems to be tested, including the extent of tests*
 - a. Provide a list of equipment and systems to be tested.
 - b. Describe the range and extent of tests to be performed for each system component, and interface between systems
 3. *Functions to be tested* - Provide example functional test procedures to identify the level of testing detail required.

4. *Conditions under which the test shall be performed* - Identify the conditions under which the major operational system functions are to be tested, including:
 - a. Normal and part-load operations.
 - b. Seasonal testing requirements.
 - c. Restart of equipment and systems after power loss.
 - d. System alarm confirmations.
 5. *Measurable criteria for acceptable performance* - Include measurable criteria for acceptable performance of each system to be tested.
- D. Commissioning Team Information** - Provide a contact list for all Commissioning team members, including but not limited to:
1. Owner and/or owner's representative.
 2. Architect and engineers.
 3. Designated commissioning representative.
 4. General contractor, sub-contractors, and construction manager.
- E. Commissioning process activities, schedules and responsibilities**
1. Establish prescribed commissioning process steps and activities to be accomplished by the Cx team throughout the design to occupancy.
 2. Define the roles and responsibilities for each member of the Cx team for each phase of the work,
 3. List the required Cx deliverables, reports, compliance documents, and verifications expected at each stage of the commissioning effort.
 4. Include the confirmation process for the O&M manual, systems manual and the facility operator and maintenance staff training.

12.6.4 Enforcement

At their discretion, the building official confirms demonstrated compliance at *Plan Review* by a receipt of a copy of the Commissioning Plan

12.7 Functional Performance Testing

§120.8(g)

Functional performance tests shall demonstrate the correct installation and operation of each component, system, and system-to-system interface in accordance with the acceptance test requirements. Functional performance testing reports shall contain information addressing each of the building components tested, the testing methods utilized, and include any readings and adjustments made.

12.7.1 Intent

Develop and implement the functional performance tests to document (as set forth in the Commissioning Plan) that all components, equipment, systems, and system-to-system interfaces were installed as specified, and operate according to the OPR, BOD, and plans and specifications.

The following systems to be functionally tested are listed in the BOD:

1. HVAC systems and controls.
2. Indoor lighting system and controls.
3. Water heating system and controls.
4. Building Envelope Components.

12.7.2 Existing Law or Regulation

Acceptance testing requirements call for functional testing of some systems and equipment. Refer to Chapter 13, Acceptance Requirements, in this manual for further guidance.

Although functional performance testing for commissioning under §120.8 is related to acceptance testing, the systems to be functionally tested are based upon systems described in the BOD. Not all of the systems described in the BOD will have acceptance testing requirements per the Energy Standards. Conversely, there may be systems listed in the BOD which do have acceptance testing requirements, such as lighting controls. To meet the acceptance testing requirements, acceptance tests must be performed by a certified Acceptance Test Technician as described in Chapter 13.

12.7.3 Compliance Method

Compliance is demonstrated by developing and implementing test procedures for each piece of commissioned equipment and interfaces between equipment and systems according to the building-specific Commissioning Plan. Tests should include verification of proper operation of all equipment features, each part of the sequence of operation, overrides, lockouts, safeties, alarms, occupied and unoccupied modes, loss of normal power, exercising a shutdown, startup, low load through full load (as much as possible) and back, staging and standby functions, scheduling, energy efficiency strategies, and loop tuning. Acceptance Requirements, discussed in Chapter 13, are required and will contribute toward compliance with §120.8(g), but do not cover all necessary testing.

Elements of acceptable test procedures include:

1. Date and Party – Identification of the date of the test and the party conducting the test.
2. Signature Block – Signature of the designated commissioning lead and the equipment installing contractor attesting that the recorded test results are accurate.
3. Prerequisites – Any conditions or related equipment checkout or testing that needs to be completed before conducting this test.
4. Precautions – Identification of the risks involved to the test team members and the equipment and how to mitigate them.
5. Instrumentation – Listing of the instrumentation and tools necessary to complete the test.
6. Reference – In each procedure item, identify the source for what is being confirmed (e.g., sequence of operation ID, operating feature, specification requirement, etc.).
7. Test Instructions – Step-by-step instructions of how to complete the test, including functions to test and the conditions under which the tests should be performed.
8. Acceptance Criteria – Measurable pass / fail criteria for each step of the test, as applicable.

9. Results – Expected system response and space to document the actual response, readings, results and adjustments.
10. Return to Normal – Instructions that all systems and equipment are to be returned to their as-found state at the conclusion of the tests.
11. Deficiencies – A list of deficiencies and how they were mitigated.

12.7.4 Enforcement

At their discretion, the building official confirms demonstrated compliance during *Field Inspection* by either:

1. Receipt of a copy of the completed and signed Functional Performance Tests that indicate any deficiencies have been corrected (optional).
2. Review of acceptance certificates (NRCA's) attesting that the Functional Performance Tests have been completed and any deficiencies corrected. Although there are no field forms for commissioning requirements, authorities having jurisdiction can review issues logs or the certificates of acceptance to verify field testing was completed and issues resolved.

12.8 Documentation and Training

§120.8(h), *Documentation and Training.*

A Systems Manual and Systems Operations Training are required.

§120.8(h)1, *Systems Manual.*

Documentation of the operational aspects of the building shall be completed within the Systems Manual and delivered to the building owner or representative and facilities operator. The Systems Manual shall include the following:

1. Site information, including facility description, history, and current requirements.
2. Site contact information.
3. Instructions for basic O&M, including general site operating procedures, basic troubleshooting, recommended maintenance requirements, and a site events log.
4. Description of major systems.
5. Site equipment inventory and maintenance notes.

A copy of all special inspection verifications required by the enforcing agency or the Energy Standards.

12.8.1 Intent

The Systems Manual documents information focusing on the operation of the building systems. This document provides information needed to understand, operate, and maintain the equipment and systems and informs those not involved in the design and construction of the building systems. This document is in addition to the record construction drawings, documents, and the O&M Manuals supplied by the contractor. The Systems Manual is assembled during the construction phase and available during the contractors' training of the facility staff.

The systems operation training verifies that a training program is developed to provide training to the appropriate maintenance staff for each equipment type and/or system and this training program is documented in the commissioning report. The systems operations training program is specified in the project specifications for the major systems listed. The System Manual, O&M documentation, and record drawings are prepared and available to the maintenance staff prior to implementation of any training or the development of a written training program. The training program is to be administered by the commissioning coordinator or other responsible party when the appropriate maintenance staff is made available to receive training.

12.8.2 Compliance Method

Compliance is demonstrated by providing the Systems Manual. The information in the Systems Manual includes the following information:

A. Site information, including facility description, history and current requirements

1. Site Information
 - a. Location of property - Address
 - b. Site acreage
 - c. Local utility information:
 - i. Water service provider
 - ii. Natural/LPG gas service provider
 - iii. Electrical service provider
 - iv. Telecommunications service provider
 - v. Other service provider
2. Facility Description
 - a. Use/Function
 - b. Square footage
 - c. Occupancy Type
 - d. Construction Type
 - e. BOD
 - f. Location of major systems & equipment
3. Project History
 - a. Project requirements
 - i. Owner's Project Requirements (OPR)
 - ii. Basis of Design (BOD)
 - b. Project undocumented events
 - c. Record Drawings & Documents
 - d. Final control drawings and schematics
 - e. Final control sequences
 - f. Construction documents - Location or delivery information:
 - i. Mechanical & electrical drawings
 - ii. Specifications
 - iii. Submittals

- iv. Project change orders and information
- 4. Current requirements
 - a. Building operating schedules
 - b. Space temperature, humidity, & pressure, CO₂ setpoints
 - c. Summer and winter setback schedules
 - d. Chilled & hot water temperatures
 - e. As-built control setpoints and parameters

B. Site contact information

- 1. Owner information
- 2. Emergency contacts
- 3. Design Team: architect, mechanical, engineer, electrical engineer, etc.
- 4. Prime contractor contact information
- 5. Subcontractor information
- 6. Equipment supplier contact information

C. Basic operation & maintenance, including general site operating procedures, basic trouble shooting, recommended maintenance requirements site events log

- 1. Basic operation
 - a. Written narratives of basic equipment operation
 - b. Interfaces, interlocks and interaction with other equipment and systems
 - c. Initial maintenance provide by contactor
- 2. General site operating procedures
 - a. Instructions for changes in major system operating schedules
 - b. Instructions for changes in major system holiday & weekend schedules
- 3. Basic troubleshooting
 - a. Cite any recommended troubleshooting procedures specific to the major systems and equipment installed in the building.
 - b. Manual operation procedures
 - c. Standby/Backup operation procedures
 - d. Bypass operation procedures
 - e. Major system power fail resets and restarts
 - f. Trend log listing
- 4. Recommended maintenance events log
 - a. HVAC air filter replacement schedule & log
 - b. Building control system sensor calibration schedule & log
- 5. Operation & Maintenance Manuals - Location or delivery information

D. Major Systems

1. HVAC systems & controls
 - a. Air conditioning equipment (chillers, cooling towers, pumps, heat exchanges, thermal energy storage tanks, etc)
 - b. Heating equipment (boilers, pumps, tanks, heat exchanges, etc.)
 - c. Air distribution equipment (fans, terminal units, accessories, etc.)
 - d. Ventilation equipment (Fans, accessories, and controls)
 - e. Building automation system (workstation, servers, panels, variable frequency drives, local control devices, sensors, actuators, thermostats, etc.)
2. Indoor lighting systems & controls
 - a. Lighting control panels
 - b. Occupancy sensors
 - c. Daylight harvesting systems
3. Renewable energy systems
 - a. Photovoltaic panels & inverters
 - b. Wind powered electrical generators & inverters
4. Landscape irrigation systems
 - a. Water distribution diagrams
 - b. Control system
5. Water reuse systems
 - a. Reclaimed water system for indoor use
 - b. Reclaimed water for irrigation use

E. Site equipment inventory and maintenance notes

1. Spare parts inventory
2. Frequently required parts and supplies
3. Special equipment required to operate or maintain systems
4. Special tools required to operate or maintain systems

F. A copy of all special inspection verifications required by the enforcing agency of this code**G. Other resources and documentation**

While not required, an Issues Log could be a useful tool to keep track of the status of equipment repairs and it should be maintained by the facilities indefinitely. The log, in conjunction with an equipment inventory, can be used to track and manage issues associated with specific pieces of equipment or systems over time. An Issues Log is a formal and ongoing record of problems or concerns discovered within a facility and the recommended resolution of those problems and concerns. This living document could be created by the Cx team and maintained throughout the course of the investigation and implementation phase of a Cx project. The Issues Log should list the following categories, at a minimum:

1. Issue item number
2. Building name or number
3. Floor
4. Location or room number
5. Equipment tag
6. Observation method
7. Issues description
8. Recommended resolution
9. Resolution responsibility
10. Action taken
11. Date of action taken
12. Resolution status
13. Verified by
14. Verification date

12.8.3 Enforcement

At their discretion, the building official confirms demonstrated compliance during *Field Inspection* by a receipt of a copy of the Systems Manual.

12.9 Systems Operations Training

§120.8(h)2

The training of the appropriate maintenance staff for each equipment type or system shall be documented in the commissioning report. Training materials shall include the following:

1. System and equipment overview (i.e. what is the equipment, its function, and with what other systems or equipment does it interface).
2. Review and demonstration of operation, servicing, and preventive maintenance.
3. Review of the information in the Systems Manual.
4. Review of the record drawings on the systems and equipment.

12.9.1 Compliance Method

The written training program includes the following:

- Learning goals and objectives for each session.
- Training agenda, topics, and length of instruction for each session.
- Instructor information and qualifications.
- Location of training sessions (onsite, off-site, manufacturer's or vendor's facility).
- Attendance forms.
- Training materials.

- Description on how the training will be archived for future use that includes:
 - A. Systems/equipment overview**
 1. Review OPR and BOD related to the major systems and equipment
 2. Describe system type and configuration
 3. Explain operation of all major systems and equipment and how it interfaces with other systems and equipment
 4. Describe operation of critical devices, controls and accessories
 5. Review location of the major systems and equipment
 6. Describe operation of control system for each system, location of critical control elements, and procedures to properly operate control system
 7. Review recommendations for implementation to reduce energy and water use
 - B. Review and demonstration of servicing/preventive maintenance**
 1. Explain location or delivery contact of the Operation & Maintenance manuals
 2. Review of all manufacturer's recommended maintenance activities to maintain warranty
 3. Review and demonstrate frequent maintenance activities (air filter replacement, lubrication, fan belt inspection and/or replacement, condenser water treatment, etc.), and suggested schedule
 4. Review and demonstrate typical servicing procedures and techniques (electrical current, pressure, and flow readings, calibration procedures, point trending, power fail restart procedures, etc.)
 5. Locate, observe and identify major equipment, systems, accessories and controls
 6. Review emergency shut-offs and procedures
 - C. Review the Systems Manual**
 1. Describe use of Systems Manual
 2. Review elements of Systems Manual
 3. Explain how to update and add revisions to Systems Manual
 - D. Review record drawings on the systems/equipment**
 1. Explain location or delivery contact of the record drawings
 2. Review record drawings, revisions, and changes to original design drawings
 3. Review equipment schedules and compare with actual installed systems

12.9.2 Enforcement

At their discretion, the building official confirms demonstrated compliance during *Field Inspection* by:

1. In the event of appropriate maintenance staff is made available to receive training for each equipment type and/or system installed in the building, receipt of a copy of the written training program and completed attendance forms.

2. In the event of appropriate maintenance staff is unavailable to receive training for each equipment type and/or system installed in the building, receipt of a copy of the training program provided to the owner or owner's representative.

12.10 Commissioning Report

§120.8(j)

A complete report of commissioning process activities undertaken through the design, construction and reporting recommendations for post-construction phases of the building project shall be completed and provided to the owner or representative.

12.10.1 Intent

The Commissioning Report documents the commissioning process and test results. The report includes confirmation from the commissioning coordinator verifying that commissioned systems meet the conditions of the OPR, BOD, and Contract Documents.

12.10.2 Compliance Method

The components of the Commissioning Report include the following and are defined as follows:

- A. Executive summary of process and results of commissioning program – including observations, conclusions and any outstanding items.
- B. History of any system deficiencies and how resolved
 1. Include outstanding deficiencies and plans for resolution
 2. Include plans for seasonal testing scheduled for a later date
- C. System performance test results and evaluations
- D. Summary of training process completed and scheduled
- E. Attach commissioning process documents
 1. Commissioning Plan
 2. OPR
 3. BOD
 4. Executed installation checklists
 5. Executed Functional Performance Test (FPT) compliance documents
 6. Recommendations for end-of-warranty review activities

12.10.3 Enforcement

At their discretion, the building official confirms demonstrated compliance during *Field Inspection* by a receipt of a copy of the Commissioning Report.