



01810

General Commissioning

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A. Summary

1. When required by Yale University, follow the commissioning procedures contained in this section. For limited project scope, commissioning may be selectively applied by the University.
2. This section contains general requirements for commissioning building systems, subsystems, and equipment to ensure reliable, safe, and secure operation. The commissioning process verifies that systems are complete and functioning properly upon project completion and that the Yale University staff has received appropriate system documentation and training.
3. As part of the commissioning process, Yale University may choose to follow the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Program requirements, which require fundamental building systems commissioning, as well as additional commissioning. For further information related to Yale University's sustainable design guidelines, see [Section 01352: Sustainable Design Requirements](#)



B. System Design and Performance Requirements

1. Commissioning is a quality-focused process for enhancing the delivery of a project.¹ Commissioning helps the project team to understand project goals and take logical steps along the way to ensure and document that those goals are met.
2. Yale University commissioning is a quality-focused process that targets:
 - Documentation
 - Testing
 - Training
3. Through documentation, commissioning ensures acceptance that all building or facility systems perform interactively. This interactive performance must be in accordance with Yale University's design intent, the designer's documentation, and Yale University's operational needs for documentation and operating personnel training.
4. Commissioning may be performed by the design engineer, Yale University personnel, or a third-party commissioning consultant. For complex projects, Yale University prefers a third-party consultant contracted directly to the University.

¹ ASHRAE Guideline 0-200X, "The Commissioning Process"



C. Extent of Commissioning

1. Ideally, commissioning activities begin during the design phase of the project and proceed through the warranty period. The four phases of commissioning at Yale University are design, construction, acceptance, and warranty.
2. Each project requires a customized approach. The Yale University project team develops a project-specific list of systems to be commissioned. Building systems that affect life safety, energy consumption, water usage, and indoor environmental quality should generally be commissioned. Table 1 lists general, mechanical, and electrical systems that are representative of systems that may be commissioned to verify full conformance with Yale University's project requirements and design intent.

Table 1. Representative Systems, Subsystems, and Equipment

General Systems Commissioning
<ul style="list-style-type: none">• Mechanical room floor over critical spaces• Building thermal and moisture envelope ²• Equipment• Doors and windows• Life safety and personnel egress systems• Conveying systems (functional testing oversight by Yale University fire marshal and elevator consultant)• Telecommunications systems

² Tseng, Paul C. "LEED, the Building Envelope, and Commissioning"



Table 1. Representative Systems, Subsystems, and Equipment—Continued

Mechanical Systems Commissioning
<ul style="list-style-type: none">• Chilled and condenser water systems• Process chilled water system• Utility metering (chilled water and condensate)• Air handling units, including glycol preheat/heat recovery systems• Humidification system• Exhaust air handling units• Fans—exhaust, return, and transfer• Terminal units, including VAV boxes, CV boxes, reheat coils, unit heaters, FCUs, baseboard radiation, and radiant panels• Heating hot water system• Steam system, including PRVs and condensate system• Building automation system• Laboratory air control sequences, including fume hood controls• Room pressurization• Plumbing system• RO/DI system• Vacuum systems• Lab neutralization system• Lab waste duplex lift station• Compressed air system• Domestic hot water heaters and pumps• Grey water system• Sanitary lift station• Backflow preventers• Fire protection/fire pumps



Table 1. Representative Systems, Subsystems, and Equipment—Continued

Electrical Systems Commissioning
<ul style="list-style-type: none">• Building main electrical service switchgear, switchboard, or substation• Major switchboard with breakers rated 400 A or higher• Normal power double-ended substations• Outdoor, liquid type, pad-mounted transformers• Alternate power switchgear• Lighting control systems• Automatic transfer switches• Major switchboards or panelboards following ATS• Emergency power system MCC• Normal power outage simulation tests• Emergency switchgear or switchboard• Emergency panels, including emergency power outlets• Emergency lighting, exit sign and lighting control (testing oversight by the Yale University fire marshal)• Fire alarm system (tests are performed by Yale University personnel)• Security system (tests are performed by Yale University personnel)



D. General Commissioning Activities

The rest of this section provides supplementary information about the four phases of commissioning (design, construction, acceptance, and warranty) shown on the Yale University Commissioning Process flow chart. The general commissioning activities described in this paragraph apply to two or more phases of the Yale University commissioning process. These activities are not described again in the subsequent paragraphs associated with commissioning activities specific to each phase. The Yale University project manager determines which commissioning activities are required on a project-by-project basis.

1. Commissioning Scheduling Activities and Regular Reviews

(See design phase activity D11, construction phase activities C3 and C4, and acceptance phase activity T9 on the [Yale University Commissioning Process Flow Chart](#).)

- a. Immediately following the commissioning kickoff meeting, the commissioning authority, in concert with the Yale University project manager, establishes regularly scheduled commissioning coordination meetings. The purpose of these meetings, in coordination with construction meetings, is to establish lines of communication, determine the routing of submittals and documents, facilitate maintenance of the schedule, and provide a forum for discussion of action items. Regular reviews are conducted throughout the project during construction team status meetings or commissioning coordination meetings.
- b. The commissioning authority lends their expertise with respect to timing and duration of the various commissioning tasks and works with the construction manager to incorporate commissioning into the master schedule. The commissioning authority reviews the schedule periodically for information regarding progress for upcoming activities, submissions, and any issues that might impact the successful and timely completion of commissioning.



2. Commissioning Action Item List

(See design phase activity D12, construction activity C15, and acceptance phase activity T19 on the [Yale University Commissioning Process Flow Chart](#).)

The commissioning authority tracks scheduled commissioning-related issues and functional performance testing. The commissioning authority also develops and maintains an action item list and submits it to the commissioning team on a regular basis for information and appropriate responses.

3. Change Order Reviews and other Construction Phase Documentation

(See construction phase activity C13 and acceptance phase activity T7 on the [Yale University Commissioning Process Flow Chart](#).)

During the construction and acceptance periods, the commissioning authority reviews change orders, requests for information, supplemental instructions, and meeting minutes for equipment and/or systems that are to be commissioned. The commissioning authority reviews the documents for issues or directives that could impact a system's ability to comply with the design intent. In addition, the commissioning authority reviews maintainability issues and incorporates designer-approved changes into the system readiness checklists and final functional test procedures.

4. Construction Team Status Meetings

(See construction phase activity C14 and acceptance phase activity T8 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority attends the construction team status meetings periodically to obtain information on construction progress. These meetings are typically facilitated by the construction manager.
- b. The commissioning authority and Yale University determine the number of meetings to be conducted and attended.



5. Design Intent Document Update

(See Design Phase activity D9, Construction Phase Activity C17, and Acceptance Phase Activity T13 on the [Yale University Commissioning Process Flow Chart](#).)

Due to the evolving nature of all design and construction projects, the design intent document is modified during the design process if budgeting and scheduling decisions necessitate a change in expected system performance. At that time, Yale University and the designers discuss and document an owner-approved change to the design intent document.

6. Commissioning Record Book Maintenance

(See Design Phase activity D13, Construction Phase Activity C18, and Acceptance Phase Activity T14 on the [Yale University Commissioning Process Flow Chart](#).)

The commissioning authority maintains a record of commissioning activities throughout the design, construction, and acceptance testing and training periods. Recorded information and issues aid in creating and tracking the documentation to be included in the commissioning report.



E. Design Phase Commissioning

1. Discovery Phase

(See design phase activity D1 on the [Yale University Commissioning Process Flow Chart](#).)

Design phase commissioning involves completing a project-specific commissioning plan. Questions that must be asked of Yale University include:

- As a cost-saving measure, can the facility’s operations and maintenance staff undertake some of the process management tasks, training oversight, or other activities, with the commissioning authority acting as a “coach”?
- Will the systems testing strategy be to test all systems or conduct random sampling?
- Will contractors be penalized for failed tests?
- What are the final deliverables?

2. Commissioning Plan

(See design phase activity D2 on the [Yale University Commissioning Process Flow Chart](#).)

1. The commissioning plan defines the commissioning process and identifies the commissioning activities for a specific project. Among other things, the plan outlines the organization’s structure, the allocation of resources, and the documentation requirements of the commissioning process. The plan also identifies the project phases and lists the commissioning team members, their commissioning-related responsibilities during each phase, and the expected deliverables from each team member.
2. The commissioning authority prepares the plan at the beginning of their involvement in the project—ideally during conceptual or schematic design—and develops it in greater detail as the project progresses through its various phases. The plan is strictly a process-roadmap for commissioning activities and does not include such items as detailed checklists, test procedures, and forms, which are identified and developed during the commissioning activities defined in the plan.
3. See the sample [Commissioning Plan](#).



3. Design Phase Commissioning Kickoff Meeting

(See design phase activity D3 on the [Yale University Commissioning Process Flow Chart](#).)

The design phase commissioning kickoff meeting is an opportunity for the commissioning authority and Yale University to present the commissioning plan to the entire design phase project team (Yale University project manager, designers, O&M staff, construction manager, and other special consultants). During the meeting, project team members are given an overview of the commissioning process and informed of their roles and responsibilities, the purpose of the design intent document, future maintenance provisions, and design review protocols. Although the project team continues to learn about commissioning throughout the entire project, the overview serves to broaden their perspective and explains the benefits of participating in the commissioning process.

4. Design Intent Document

(See design phase activity D4, construction phase activity C17, and acceptance phase activity T13 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The design intent document describes Yale University's project requirements and identifies system performance goals in quantitative and verifiable terms. In addition, the document includes the university's vision for the facility, the facility's functional requirements, and the university's expectations regarding the facility's design, use, and operation.
- b. The purpose of the design intent document is to focus all project activities on achieving the desired outcome. It also serves as the reference for evaluating success and quality in all phases of the project and becomes the benchmark for system maintenance and repair/replacement decisions. In addition, the design intent document serves as the basis for preparing system design narratives and design documents that contain the calculations, rationale, and assumptions necessary to achieve the design intent.
- c. The Yale University project manager requests the design intent document from the design professional. The designer—in consultation with Yale University, and with input from facility users and operators—prepares the design intent document, based on an understanding of the project requirements. The commissioning authority reviews and approves the document.



- d. The design intent document is updated periodically during the design and construction phases of the project to reflect changes in project requirements. A final update occurs during the acceptance phase. Yale University reviews and approves all changes, and the commissioning authority documents them.
- e. Items to consider for inclusion in the design intent document are listed in the example [Design Areas and Owner Project Requirement \(Design Intent\) Categories table](#). See also the sample [Design Intent Document—Space Conditions form](#) used for recording space conditions.

5. Design Reviews

(See design phase activity D6 on the [Yale University Commissioning Process Flow Chart](#).)

- a. Design documents are reviewed by other Yale University and regulatory agency representatives at various project milestones, such as schematic design, design development and construction documents. Yale University determines the number of reviews, which depends on project type and scope.
- b. The commissioning authority reviews the design documents to answer to the following questions.
 - If constructed as designed, will the systems meet the design intent?
 - Are the systems (as designed) “commissionable”? Have the designers included the features necessary to verify that the systems will meet the design intent at the end of construction?
 - Are the system components accessible and maintainable? Are the specified O&M documentation requirements adequate? Are the specified operator training requirements adequate?
 - Are the design documents unambiguous? Do the drawings and specifications clearly detail requirements, or do they leave a lot up to the imagination and creativity of the contractor?
- c. The design engineers review the commissioning authority's comments and submit their responses, through the construction manager, to the commissioning authority and Yale University.
- d. See the sample [Design Review form](#) used for design reviews.



6. Technical Design Review

(See design phase activity D6b on the [Yale University Commissioning Process Flow Chart](#).)

- a. Technical design reviews are conducted at several stages in a project. The number and type of reviews are based on project scope, and reviews may not be required on some projects. An electrical load flow analysis review (described in the following paragraph) is one type of technical design review that may be conducted, as well as reviews for other engineering disciplines.
- b. Under normal conditions, a load flow analysis determines real and reactive power flow in power system circuits. It also determines bus voltages in all possible operating conditions and provides solutions to potential system deficiencies. A review of the analysis by the commissioning authority confirms that the main electrical system components are included in the documentation used by the project team and by operations and maintenance personnel in making future system changes and in conducting system evaluations.
- c. Yale University determines the extent of the commissioning authority's participation in technical design reviews. As a participant, the commissioning authority's role is to review and comment on the designs, focusing on the clarity of the design documents and on the designated system's ability to meet the design intent criteria.

7. Commissioning Specification

(See design phase activity D5 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority, working with the design team specification authors, must develop a commissioning specification for each project for inclusion in Division 1 of the design team's project specification books. The draft specification extracts the contractors' responsibilities from the commissioning plan and converts them into standard specification language and format, thus binding the contractors to the commissioning process through their normal contracting document. The commissioning specification is updated with each issuance of the design documents.



- b. The commissioning specification must reflect the bidding contractors' commissioning responsibilities (scope, process, rigor of testing) that Yale University requires. Yale University may direct the commissioning authority to incorporate features that enhance the university's involvement and contribute to the scope of training requirements or processes that increase the value of the project. The final outcome is a commissioning specification that describes the preferred approach to commissioning and identifies:
- The systems to be commissioned
 - The preferred approach to commissioning
 - Required documents and forms
 - Detailed testing procedures
 - Training requirements
 - Commissioning schedule sign-off requirements
 - All other information needed to complete the commissioning process
- c. In the sample [commissioning specification](#), LEED (Leadership in Energy and Environmental Design) Certification is a requirement. Sustainable design, which LEED supports, is a Yale University project design requirement. The decision to pursue LEED certification depends on the unique requirements of each project. See [Section 01352: Sustainable Design Requirements](#) for additional information regarding sustainable design.

8. Commissioning Requirements in Technical Specifications

(See design phase activity D7 on the [Yale University Commissioning Process Flow Chart](#).)

The commissioning authority reviews the design team's technical specifications and suggests inclusions that alert the contractor to specific commissioning requirements and document coordination requirements.



9. Training Plan Development

(See design phase activity D8 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority reviews the training requirements included in the design team's technical specifications and meets with Yale University to understand the nature and extent of the necessary training. In addition, the commissioning authority customizes the commissioning specification and suggests modifications to the technical specifications that reflect the university's training preferences. The specification review and recommendations focus on making the training requirements measurable and enforceable.
- b. See the sample [commissioning specification](#) for an example of the Operation and Maintenance Training Plan form used by contractors to submit their intentions for each training session and used by Yale University in reviewing, approving, and documenting the successful delivery of each training session.

10. Preventive Maintenance and Equipment Data Requirements

(See design phase activity D10 on the [Yale University Commissioning Process Flow Chart](#).)

- a. Researching preventive maintenance and data retrieval requirements ensures that they are included in the bid specifications. The installation contractors or equipment vendors supply all of the data required to populate Yale University's preventive maintenance system with information on new equipment. The commissioning authority and Yale University determine what data is needed and how it should be presented. See the sample Mechanical–Electrical Data Retrieval form in the sample [commissioning specification](#).
- b. During construction, the commissioning authority collects the data retrieval forms submitted by the contractors and reviews them for completeness.

11. System Readiness Checklists and Verification Test Procedures

(See design phase activity D14 on the [Yale University Commissioning Process Flow Chart](#).)



- a. The commissioning authority develops all required system readiness checklists. The checklists are used to demonstrate complete system installation and readiness for operational testing. At the end of construction, the contractor uses the checklists to certify that the work is complete and the system is ready for independent verification testing.
- b. The commissioning authority also develops preliminary verification test procedures—the functional component of testing. The test procedures provide the contractors with repeatable, unambiguous acceptance criteria that clearly define the level of rigor necessary in demonstrating system performance.
- c. The system readiness checklists and verification test procedures are incorporated into the commissioning specification. Sample of these documents are included in the sample [commissioning specification](#).

12. 100-Percent Design Review Backcheck

(See design phase activity D15 on the [Yale University Commissioning Process Flow Chart](#).)

During the backcheck, the commissioning authority reviews the final design documents for engineer responses and the inclusion of outstanding commissioning authority comments.

F. Construction Phase Commissioning

1. Pre-Bid Meeting

(See construction phase activity C1 on the [Yale University Commissioning Process Flow Chart](#).)

During the pre-bid meeting, Yale University introduces the design team to prospective bidders. The commissioning authority describes the benefits of the commissioning, and provides a 5–10 minute overview of the commissioning process. In addition, the commissioning authority presents the system readiness checklists to the group, reviews the required verification testing procedures, and answers any questions.

2. Pre-Construction Meeting

(See construction phase activity C2 on the [Yale University Commissioning Process Flow Chart](#).)



During the pre-construction meeting, Yale University introduces the design team and commissioning authority to the installation contractors. The commissioning authority briefly reviews the commissioning specification with the construction team, answers their questions, and is prepared to discuss how the contractors benefit from the commissioning process. In addition, the construction phase commissioning kickoff meeting is scheduled. The kickoff meeting should be held within two to six weeks of the pre-construction meeting.

3. Construction Phase Commissioning Kickoff Meeting

(See construction phase activity C3 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority chairs the construction phase commissioning kickoff meeting, which is attended by all commissioning team members, including all responsible contractors and subcontractors. The commissioning authority presents a detailed overview of the commissioning process described in the commissioning plan and in the commissioning specification section of the construction documents.
- b. At this meeting the commissioning authority in concert with the Yale Project Manager would establish regularly scheduled commissioning coordination meetings. This meeting establishes lines of communication, routing of submittals and documents, maintenance of schedule, and discussion of action items.

4. Shop Drawing Reviews

(See construction phase activity C5 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority, concurrently with the designers, reviews the equipment and system shop drawing submittals for systems being commissioned. The commissioning authority submits their comments, which based primarily on the four design review areas defined under the design development review task, to the designers. If the designers agree with the commissioning authority, they incorporate these comments into their formal response back to the contractors.
- b. An ATC submittal review is mandatory.



5. Coordination Drawing Review

(See construction phase activity C6 on the [Yale University Commissioning Process Flow Chart](#).)

The commissioning authority reviews coordination drawings and documents, such as ductwork and piping coordination drawings or over-current protection coordination studies, to verify that equipment installations conform to the design intent and are easily accessible for on-going maintenance.

6. Equipment O&M Manual Review

(See construction phase activity C7 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning specification must require that the contractors submit operations and maintenance (O&M) manuals within two to three months after approval of all equipment submittals. Within the scope of systems being commissioned, the commissioning authority reviews all O&M manuals for completeness, accuracy, clarity, and project-specific customization. The commissioning authority may also gather test parameter data for use during final functional testing. The O&M manuals are then available for use during training.
- b. The O&M manual review is project-specific and cannot be completed until the coordination drawings and equipment submittals have been reviewed and accepted.

7. Review Equipment Training Plan

(See construction phase activity C8 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority works with the contractors and Yale University to establish training dates; review contractor training plans, agendas, and outlines for all equipment training sessions required by contract; and assist in customizing the training to meet the needs of the building's operations and maintenance staff. The equipment training sessions focus on the operation and maintenance of individual equipment.



- b. Training is project-specific and depends on the scope of services. Commissioning authority participation in training activities must be discussed with Yale University.
- c. Training cannot be completed until the coordination drawings and equipment submittals have been reviewed and accepted.

8. Test, Adjust, and Balance Execution Plan Review

(See construction phase activity C9 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority, concurrently with the designers, reviews the execution plan, calibration information, and documentation for the planned testing and balancing approach and the instruments to be used in performing the balancing work. The execution plan must be submitted before starting any balancing work.
- b. In many cases, the designers specify that the test, adjust and balance (TAB) contractor submit a TAB execution plan for approval before starting their fieldwork. The commissioning authority reviews the final TAB report to finalize the functional performance test procedures.
- c. The test and balance approach must address such questions as:
 - (1) Does the plan include the need for the balancer to obtain any equipment from the controls contractor in order to balance a system?
 - (2) Does the balancer know how to use the equipment provided by the controls contractor?
 - (3) Must the controls contractor be on-site while the test and balance process is occurring?
 - (4) Does the test and balance contractor understand the direct digital control (DDC) system know how to enter and override control setpoints?
 - (5) Does the test and balance contractor understand project phasing and the need to visit the project site multiple times in order to accommodate the phasing process?



9. Electrical Test Agency Test Plan Review

(See construction phase activity C10a on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority reviews the electrical test agency test plan to confirm that electrical testing will meet the requirements of the design intent. The test plan review compares proposed tests to International Electrical Testing Association standards and other applicable standards as required by the design intent. In addition, the review helps confirm that required test results are documented properly for acceptance and as a baseline for future operations and maintenance needs.
- b. Some steps in the functional performance tests developed by the commissioning authority may require special test instruments. The electrical subcontractor may be required to retain an electrical test agency. If one is retained, the electrical test plan is required to finalize functional performance tests procedures.

10. Technical Design Review

(See construction phase activity C10b on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority reviews and comments on the designs at several stages. The reviews focus on the ability of the designated systems to achieve the design intent criteria. The commissioning authority also reviews the design documents for clarity.
- b. Technical design reviews are specific, may be multi-disciplinary, and might not be required on all projects. The decision to conduct a review should be based on the size of the commissioning project. Participation by the commissioning authority in technical design reviews must be discussed with Yale University.



- c. The following three technical design reviews serve as representative examples of the types of reviews that may be conducted.
- (1) Short-circuit and power coordination study review.
 - (2) Electrical system short-circuit analysis review.
 - (a) The commissioning authority confirms that the study reports include adequate detail and that the resulting documentation provides an adequate reference for system evaluation, operations, and maintenance. The commissioning authority also confirms that the study includes a comparison between short circuit analysis results and equipment ratings, which ensures that the supplied distribution equipment meets specification requirements.
 - (b) Documentation in the reports should include one-line diagrams, explanation of assumptions, utility-provided data, computer analysis program data, manufacturer's time current curves, original equipment manufacturer cut sheets, a listing of all final settings, and an explanation for the final settings of each function.
 - (3) Electrical harmonic study.
 - (a) The commissioning authority reviews electrical harmonic studies when 50 kva or greater variable-frequency drives are proposed for the project. The studies must be based on IEEE 519-1992 standards.
 - (b) System one-line input data includes emergency generator and primary fault current data. The study must include:
 - All input data and assumptions
 - An explanation of the method used to perform the analysis
 - All calculations and computer analysis printouts
 - Each point of common coupling on the secondary side of the transformer that feeds that group of drives meeting the required limits
 - A system impedance diagram based on the one-line diagrams
 - A detailed description of the tests and procedures to support the calculations



11. Preventive Maintenance Retrieval Forms

(See construction phase activity C11 on the [Yale University Commissioning Process Flow Chart](#).)

- a. During construction, the commissioning authority collects and reviews the completeness of the data retrieval forms submitted by the contractors for each piece of equipment associated with the systems being commissioned.
- b. The commissioning authority tracks, receives, reviews, and accepts the equipment data retrieval forms submitted by the contractors. Acceptance is based on the contractors' forms being complete and meeting the specification requirements.

12. Field Record Drawing Review

(See construction phase activity C12 on the [Yale University Commissioning Process Flow Chart](#).)

- a. During construction, the commissioning authority must review field record drawings (“red-lines”) periodically—typically monthly. These reviews confirm the accuracy and completeness of the red-line markups prior to concealment of system elements. Attention is given to the locations of critical O&M items, such as shutoff valves, fire/smoke dampers, disconnect switches, control system instrumentation, terminal units, and access panels. Except where gross deviations are obvious, attention is not focused on the actual pipe and duct locations, if the general routing is depicted accurately.
- b. At the completion of construction, the commissioning authority compares the final as-built documents to the red-lined drawings previously reviewed and approved in the field.

13. Equipment Training Session Scheduling and Verification Testing

(See construction phase activity C16 on the [Yale University Commissioning Process Flow Chart](#).)

- a. As construction of the systems approaches completion, the commissioning authority conducts a commissioning team meeting to develop a detailed verification testing schedule.



- b. The commissioning authority convenes a meeting with the contractors and O&M supervisors to schedule the equipment training sessions. The commissioning authority also assists in coordinating training events to meet the needs of all participants and to ensure that resources are used effectively.

14. Systems Training Planning

(See construction phase activity C20 on the [Yale University Commissioning Process Flow Chart](#).)

In addition to assisting with training coordination, the commissioning authority, in conjunction with the design engineers, provides additional training for the O&M staff on the design intent of the systems being commissioned. The design intent training includes a detailed review of how the systems and sub-systems work together. The training also includes a walk-through of each building to ensure that O&M staff members are familiar with the systems and with the associated control devices.

15. Final System Readiness Checklist Development

(See construction phase activity C21 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority makes any necessary revisions to the systems readiness checklists based on the final approved submittals and all project changes, such as change orders, architectural supplemental instructions, and proposal requests. The commissioning authority submits the final system readiness checklists to the contractor for use in performing final system checkouts.
- b. The commissioning authority finalizes the checklists based on comments received during preliminary development.



16. Final Functional Performance Test Procedure Development

(See construction phase activity C21 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority, after having reviewed the approved project submittals and all project changes, such as change orders, architectural supplemental instructions, proposal requests, revises the preliminary functional test procedures to reflect the as-installed and as-programmed conditions. The contractors review their respective final functional test procedures before conducting the tests.
- b. The commissioning authority finalizes the functional test procedures and issues them for testing, based on comments received during preliminary development.

G. Acceptance Phase Commissioning

1. Equipment Training Oversight

(See acceptance phase activity T1 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The contractors deliver their respective O&M equipment training sessions. The commissioning authority is not always asked to attend and witness all of the training. Yale University's trainee representative must formally accept each training session, in writing, as being in compliance with that session's training plan. The commissioning authority collects and compiles the training plan/agenda forms.
- b. Training is project-specific, depending on the scope of services. The commissioning authority may not participate in training activities. Commissioning authority participation must be discussed with Yale University.



2. Systems Training

(See acceptance phase activity T2 on the [Yale University Commissioning Process Flow Chart](#).)

The commissioning authority plans and leads the delivery of Systems Training to supplement the equipment training provided by the contractors. Systems training consists of an explanation of the Design Intent Documentation and how the Designers' systems achieve the stated criteria. The goal of this training is to convey how all of the individual pieces of equipment are uniquely configured to operate as a "system." Such training is best delivered before the functional testing is performed, because the operators can then witness the tests and get as close to "hands-on" systems training as possible before the systems are turned over to them.

3. Contractor Test Report Tracking and Review

(See acceptance phase activity T3 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority reviews the Contractors' Test Reports to verify that each test is within the acceptable parameters identified in the contract documents. The commissioning authority maintains a current status log of all Contractors' Test Reports required to be submitted as part of the project. System functional testing must not occur until the Contractor Test Reports have been submitted and approved by the commissioning authority.
- b. This cannot be reviewed or accepted until completed Equipment Startup Reports have been submitted by the Contractor to the commissioning authority.

4. Test, Adjust, and Balance Report Review

(See acceptance phase activity T4 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority, concurrent with the Designers, reviews the Report(s) submitted by the TAB contractors as they complete their work on individual systems (not all systems need to be balanced before the reporting process begins). The commissioning authority verifies that all required data has been collected and that the measured results are in compliance with the specification and the Design Intent. The commissioning authority also verifies that all air and hydronic systems have been adjusted and are reported to be within the acceptable design values.



- b. The test and balance report also identifies specific system deficiencies that prevent proper balancing of a system. As a result, the commissioning authority issues a Corrective Action Report (CAR) to track the deficiency to resolution. The test and balance contractor is responsible for revisiting the system balancing after the deficiencies have been resolved.
- c. TAB completion is required before the contractor can complete the System Readiness Checklists.

5. Test, Adjust, and Balance Field Verification/Spot Check

(See acceptance phase activity T5 on the [Yale University Commissioning Process Flow Chart](#).)

- a. Upon completion of testing and balancing, and the commissioning authority's review and approval of the test and balance report, the test and balance contractor re-measures a random sample of air flow values and hydronic flow rates documented in the test and balance report under the direction of, and witnessed by, the commissioning authority.
- b. This is project specific and might not be included. Commissioning authority participation must be discussed with Yale University.

6. System Readiness Checklist Tracking and Review

(See acceptance phase activity T6 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The Commissioning Specification includes the Systems Readiness Checklists and must be completed by the contractors as formal notification that each system is ready for its respective verification test procedure. These checklists recognize that "systems" are usually a collaborative effort of more than one subcontractor. As such, all contractors who have a role in successfully completing a system sign-off on a single checklist that their part of the system is complete.
- b. The commissioning authority reviews the checklists to verify that they are complete as they are submitted. The commissioning authority maintains a current status log of all System Readiness Checklists required. System functional testing cannot occur until the System Readiness Checklists have been submitted and commissioning authority has approved them.



- c. System Readiness Checklists cannot be completed until TAB reports have been reviewed and accepted. Testing cannot commence until completed SRC's have been submitted and accepted.

7. Direct and Document Functional Performance Testing

(See acceptance phase activity T15 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority coordinates functional testing with the responsible contractors and Yale University's operations and maintenance staff. During the functional testing process, the contractors are responsible for performing the functional tests under the direction of the commissioning authority. Yale University O&M staff are encouraged to participate in the testing as the culmination of their training program. The commissioning authority documents the results of the all functional tests.
- b. The witnessing of testing cannot begin until the contractor has submitted and the commissioning authority has approved all necessary information and documentation.

8. Submit Daily Test Reports

(See acceptance phase activity T16 on the [Yale University Commissioning Process Flow Chart](#).)

Upon completion of testing each day, the commissioning authority prepares a summary Verification Test Report for that day. This report lists the tests performed, describes the results, and provides immediate feedback to all commissioning team members.

9. Corrective Action Reports and Logs and Correction of Deficiencies

(See acceptance phase activity T17 on the [Yale University Commissioning Process Flow Chart](#).)

- a. For each deficiency found during testing, the commissioning authority prepares a Corrective Action Report (CAR) for communicating, tracking, and documenting the status and correction of each deficiency. The commissioning authority maintains a Corrective Action Report log to track the status of each CAR.



- b. The commissioning authority gives the CAR to the Contractor who, upon correction of the problem, returns the form to the commissioning authority with an explanation of steps taken resolve the issue. Upon receipt of the completed CAR, the commissioning authority schedules and coordinates retesting with the contractors and Yale University O&M staff. The commissioning authority issues a functional test report summarizing the retesting efforts, plus any new CAR after each day of retesting. See a sample CAR and CAR Log in the [sample specification](#).

10. Trend Log Evaluation

(See acceptance phase activity T18 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority identifies specific systems that require trend logs. Trend logs provide four forms of documentation: two are measures of system evaluation and two provide long-term records.
- b. Trend logs:
 - (1) Prove the functionality of the digital control system to collect regular and continuing real time values, and proves the selected sensors work as expected.
 - (2) Reflect the performance of the mechanical and electrical systems the sensors represent. Comparing the data to similar units and to the DID affirms that the system is performing correctly.
 - (3) Establish a history of normal operations.
 - (4) Provide a detailed record of the test changes and resultant responses during functional testing.
- c. This is project specific and might not be included for the commissioning authority to review. Commissioning authority participation must be discussed with Yale University.



11. LEED Recommissioning Management Manual

(See acceptance phase activity T20 on the [Yale University Commissioning Process Flow Chart](#).)

The commissioning authority gathers and assembles contributions from all commissioning team participants, organizes the information, prepares the recommissioning manual to meet LEED requirements, and presents the manual to Yale University.

12. Final Commissioning Report

(See acceptance phase activity T21 on the [Yale University Commissioning Process Flow Chart](#).)

The commissioning authority prepares the report and includes an executive summary followed by copies of the Commissioning Plan, Design Intent Document, Commissioning Specifications, O&M Training Record, Functional Performance Test Reports, and Corrective Action Report Log. In addition, the report incorporates appendices that include Design Reviews, System Readiness Checklists, Corrective Action Reports, and blank Functional Test Procedures for future recommissioning activities.

H. Warranty Phase Commissioning

1. Deferred Test Procedures and Associated Deficiency Tracking

(See warranty phase activity W1 on the [Yale University Commissioning Process Flow Chart](#).)

The commissioning authority schedules and coordinates all system functional testing that could not be completed during the acceptance phase because of issues such as seasonal constraints, construction phasing, or tenant fit-out. Trend logs for deferred testing must be included. Similar to the initial functional testing, all deficiencies discovered during the deferred functional testing process must be tracked, logged, and brought to resolution.



2. 10-Month Checkup and Lessons Learned Facilitation

(See warranty phase activity W2 on the [Yale University Commissioning Process Flow Chart](#).)

- a. Ten months into the typical twelve-month warranty period, the commissioning authority convenes the commissioning team to meet with Yale University staff. At this meeting, the commissioning team solicits operation and maintenance staff comments, suggestions, and areas of concern regarding the systems and systems operations. The meeting generates the following:
 - Warranty items to address
 - Requests for system modifications to better meet operator and building occupant needs.
 - lessons the team learned that can be applied to future projects.
 - Systems training review
- b. This is project-specific and may not be included. Commissioning authority participation must be discussed with Yale University.

3. Benefits of Commissioning Analysis

(See warranty phase activity W3 on the [Yale University Commissioning Process Flow Chart](#).)

- a. The commissioning authority documents specific examples of how the project benefited from the commissioning process, including deficiencies discovered during the commissioning process. The analysis also documents how the commissioning process, including training, affected the ability of the building operators to control their building more efficiently.
- b. This is project-specific and might not be included. Commissioning authority participation must be discussed with Yale University.

4. Amendment to Final Commissioning Report

(See warranty phase activity W4 on the [Yale University Commissioning Process Flow Chart](#).)

The commissioning authority updates the final commissioning report to include the results of warranty period activities, including deferred testing. Recommendations made as a result of the 10-month checkup are summarized in the final commissioning report.