


EPA building commissioning guidelines

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Environmental Protection Agency
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Commissioning is an integrated, systematic process to ensure, through documented verification, that all building systems perform interactively according to the Design Intent. It is necessary that the commissioning process establish and document the Environmental Protection Agency's (EPA) criteria for system function, performance, and maintainability; as well as verify and document compliance with these criteria throughout all phases of the project. Commissioning procedures require a collaborative team effort and begin in the pre-design or planning phase, continue through the design and construction phases, and into the initial occupancy phase, including the training of operations and maintenance (O&M) staff.

Historically, the term "commissioning" has referred to the process by which the heating, ventilation, and air conditioning (HVAC) system of a building was tested and balanced according to established standards prior to acceptance by the building owner. The HVAC commissioning did not include building systems that did not directly affect the performance of the HVAC systems. Total building commissioning is a process for achieving, validating, and documenting that the performance of the total building and its systems meets the design needs and requirements of the EPA users. Because all building systems are integrated, a deficiency in one component can result in sub-optimal operation and performance among other components. Remedying these deficiencies can result in a variety of benefits including:

- Improved occupant comfort
- Energy savings
- Improved environmental conditions
- Improved system and equipment function
- Improved building operation and maintenance
- Improved building productivity

Recent studies indicate that on average the operating costs of a commissioned building range from 8 to 20 percent below that of a non-commissioned building. The one-time investment in commissioning for a building (ranging from 0.5-1.5 percent of construction costs) can result in reduced operating costs over the life of the building.

The purpose of these guidelines is to outline the commissioning process and identify roles and responsibilities. The guidelines provide information for the team involved in an EPA commissioning process including definitions of commissioning terms, an outline of the commissioning tasks, and a description of responsibilities throughout all phases of the project.

overview

Objective

The objective of commissioning is to confirm and document that a facility fulfills the functional and performance requirements of the building owner, occupants, and operators. To reach this goal, it is necessary for the commissioning process to establish and document the EPA's criteria for system function, performance, and maintainability; as well as to verify and document compliance with these criteria throughout design, construction, start-up, and the initial period of operation. For the process to work successfully, it is important that the EPA, commissioning provider, design team, contractors, and operators work together as a team throughout the project.

Definitions and Acronyms

Basis of Design (BoD). The documentation of the primary ideas and assumptions behind decisions that are made to meet the Design Intent. It responds to, and is consistent with, performance criteria specified in the Design Intent Document (Some reiteration of the Design Intent may be included). The Basis of Design is written by the design team and describes codes, standards, operating conditions, design conditions, weather data, interior environmental criteria, other pertinent design assumptions, cost goals, and references to applicable codes, standards, regulations and guidelines. The Basis of Design increases in detail as the design progresses. The Commissioning Authority reviews, comments on, and approves the design progress submissions. The Basis of Design explains how certain systems and space arrangements were chosen by the design team to satisfy the requirements of the EPA's Design Intent.

Building Automation System (BAS). The automatic system used for controlling equipment in a building. Most likely, this is a computer-based system including either pneumatic or digital components or both.

Building Systems. The architectural, structural, mechanical, electrical, and control aspects of a building along with their respective subsystems, equipment, and components.

Commissioning (Cx). Commissioning is a process that enhances the delivery of a project by verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's project requirements (design intent). In addition to uncovering deficiencies in design or installation using peer review and field verification, commissioning also results in improved energy efficiency, environmental health, and occupant safety.

Commissioning Authority (CxA). An independent party with no affiliation to the design team or participating contractors who implements the overall commissioning process.

Commissioning Final Report. The document prepared during the acceptance phase of the commissioning process after all functional performance tests are completed. It includes an executive summary, building description, the completed commissioning plan, and all documentation generated during the process along with completed commissioning test plans.

Commissioning Plan. The document, or group of documents, that defines the commissioning process at the various stages of project development. The plan must create a procedure that will verify and document that the performance of the building and its individual systems meet the owner's requirements. This document includes all aspects of the commissioning process including schedules, responsibilities, documentation requirements, and functional performance test requirements. The level of detail in the document depends on the scope of the specified commissioning activities.

Commissioning Test Plan. The document prepared for each system, piece of equipment, or energy efficiency measure that details the pre-functional test, functional performance test, and the necessary information for carrying out the testing process. The test plans are included as an appendix to the final commissioning report.

Control Strategy. An approach to controlling equipment. Usually this term refers to automated routines implemented through an energy management system that are designed to control equipment while providing maximum energy efficiency.

Pre-Functional/Construction Checklist. A checklist to ensure that the specified equipment has been provided, properly installed, and initially started and checked out adequately in preparation for full operation and functional testing (e.g., belt tension adjusted, fluids topped, labels affixed, gauges in place, sensors calibrated, voltage balanced, rotation corrected).

Construction Phase Commissioning Plan. An extension of the commissioning plan developed during the design phase that outlines the roles and responsibilities of each project team member; specifies procedures for documenting commissioning activities and resolving issues; and sets a schedule for conducting commissioning activities during the construction phase of the project. It is updated as construction progresses.

Data logger. A stand-alone, electronic data-gathering device that uses sensors to collect equipment information over time. Data collected could include temperature, pressure, current, humidity, or other operational information.

Design Intent. Design Intent defines the benchmark by which the success of a project is judged. It describes EPA's program for the planned facility and explains the rationale behind the ideas, concepts and criteria for the facility. The Design Intent Document is updated and increases in detail with each phase of the design. The initial Design Intent Document is a detailed explanation of the facility's objectives; its functional and operational needs; occupancy requirements; general quality of materials and construction; intended levels and quality of environmental control; performance criteria; environmental needs; and budget considerations and limitations. The Design Intent Document is the starting point for the development of the Basis of Design. A Design Intent Document is written by the design team in consultation with the EPA and with input from the Commissioning Authority.

Functional (Performance) Checklist. Checklist created to test the full range of operation of the equipment/systems being commissioned. The tests are carried out to determine whether all components, subsystems, systems, and interfaces between systems function in accordance with the Design Intent and within the parameters set up in the Basis of Design. "Function" includes all modes and sequences of control operation, all interlocks and conditional control responses, and all specified responses during design day and emergency conditions. Functional checklist tests are performed after construction checklists are complete.

Indoor Environmental Quality (IEQ). Refers to the total environment of a building and includes thermal comfort, proper illumination, adequate outside air ventilation, and control of indoor air pollutants.

LEED™ (Leadership in Energy and Environmental Design). A voluntary, consensus-based, market-driven building rating system that was created to provide a complete framework for assessing building performance and meeting sustainability goals based on well-founded scientific standards. The LEED rating system is organized into five environmental categories. One of them – Energy & Atmosphere – includes prerequisites and an allocated number of credits to building commissioning.

Operations & Maintenance Assessment (O&M Assessment). A systematic method for identifying ways to optimize the performance of an existing building. This assessment involves gathering, analyzing, and presenting information based on the building EPA or manager's requirements.

Payback. The length of time that an energy-efficient improvement will take to provide the full return on investment.

Performance Metrics. Verification that a specific element in the Design Intent has been met. Performance metrics are identified throughout the design of the project with as many as possible being generated during the development of the Design Intent. The design team and Commissioning Authority are responsible for developing performance metrics.

Preliminary (Design Phase) Commissioning Plan. The initial scope of work for the commissioning plan developed in the pre-design or early design phase of the project. The preliminary commissioning plan names the actual components and systems selected for commissioning. The commissioning plan developed during the pre-design phase, which outlines each team member's role and responsibilities, sets protocols for communication and reviews; specifies procedures for documenting commissioning activities and resolving issues; and sets the schedule for commissioning activities during the design phase of the project. This plan should define the extent of the commissioning process and be used to communicate it to all project participants.

Preventive Maintenance Program. A proactively implemented program that addresses equipment maintenance. Its goal is to perform maintenance tasks on a regular schedule in order to maximize the operational efficiency and lifetime of the equipment.

Retro-Commissioning/Re-Commissioning (RCx). The process of assessing, analyzing, and upgrading the operational performance of an existing building. RCx usually results in a number of low-cost or no-cost activities that save energy while maintaining or improving comfort.

Short-cycling. Equipment that goes through a complete on/off cycle too often is said to be short-cycling. Continued short-cycling operation can reduce the life cycle of equipment, waste energy, and cause ineffective control.

EPA Research,
Triangle Park, NC

List of Acronyms

A/E	Architect Engineer
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
BAS	Building Automation System
BCA	Building Commissioning Association
CM	Construction Manager
CSI	Construction Specifications Institute
Cx	Commissioning
CxA	Commissioning Authority
DDC	Direct Digital Control
EMS	Energy Management System
EPA	Environmental Protection Agency
GSFIC	Georgia State Financing and Investment Commission
HVAC	Heating Ventilating and Air Conditioning
IAQ	Indoor Air Quality
IEQ	Indoor Environmental Quality
NEBB	National Environmental Balancing Bureau
PECI	Portland Energy Conservation, Inc.
PM	Preventive Maintenance
RFI	Request for Information
RCx	Retro-Commissioning/Re-commissioning
RFP	Request for Proposal
RFQ	Request for Qualifications
TAB	Testing, Adjusting, and Balancing
USDOE	U. S. Department of Energy

Roles and Responsibilities

The roles and responsibilities as defined within the commissioning plan are in the best interest of the EPA and are essential to the successful completion of commissioning.

The following section outlines the commissioning team's roles and responsibilities throughout the commissioning process. Some may be repeated within the guideline as the various commissioning phases are expanded upon. For a quick reference outline, see the Commissioning Roles and Responsibilities Matrix in Attachment 4.

All parties are required to do the following:

- Follow the commissioning master plan and assist in the completion of commissioning tasks.
- Attend the commissioning scope meeting and additional meetings, as necessary.
- Make resources available to successfully complete commissioning tasks.
- Provide the required safety training needed to accomplish the commissioning activities.

Architect and Design Engineers (A/E)

- Read and understand the commissioning plan. This document is a critical guide for the commissioning process that will be implemented. All parties are responsible for knowing and understanding the requirements set forth in the commissioning plan.
- Throughout the commissioning process, the Commissioning Authority submits formal request for information (RFI) forms to the A/E for any issues, questions, or concerns that arise regarding the system designs. The A/E is required to provide a formal response to these RFI's. It is preferable that the A/E respond to RFIs within a maximum of two (2) weeks so that document development and functional testing are not impacted.
- Throughout the entire project, provide copies to the Commissioning Authority of all meeting minutes, RFI's, change orders, or any other document that may impact the project design and/or construction. The A/E is responsible only for the minutes of meetings that they conduct and document.
- Attach or otherwise include submittal review comments generated by the Commissioning Authority into or onto their own submittal review comments. Submittal review comments from the A/E and Commissioning Authority are returned to the contractor(s) as a single form or file.
- Provide final construction documents to the Commissioning Authority for use throughout the construction phase. These documents are to include a minimum of one set of full size drawings, one set of half size drawings, and two sets of specifications.

- Provide a representative to attend the commissioning kick-off meeting and a representative to attend every commissioning meeting. Preferably the same individual would be involved in all aspects of the commissioning process, including meeting attendance, form review, documentation approval, etc.
- Review the functional performance tests (FPT's) developed by the Commissioning Authority. The FPT's follow the sequence of operations as described in the construction documents and should therefore be functionally accurate. However, if there are test procedures that do not meet the Design Intent, the A/E must reveal these issues or conditions to the commissioning team.
- It is in the best interest of the A/E to provide a representative to witness the functional checklist/performance testing. This will allow the A/E to verify that the systems being commissioned do, in-fact, operate as intended by the design. In the event of an oversight regarding the sequence of operations, the designer's input would be invaluable and may alleviate the need for postponing functional testing.
- Provide a copy of the marked as-built documents (red line drawings), from the contractor to the Commissioning Authority for review. The A/E makes any corrections or modifications to the as-built documents so they reflect true as-built conditions as discovered by the Commissioning Authority.

Commissioning Authority (CxA)

- Coordinate the development and execution of a master plan, and observe and document which systems are functioning in accordance with the documented Design Intent and the contract documents.
- Coordinate and direct the commissioning activities in a logical, sequential, and efficient manner, using pre-functional checklists, testing protocols, centralized documentation, regular communications through an interim report and consultations with all appropriate parties, updated testing logic, and technical experts.
- Coordinate the commissioning work with the CM to verify that he/she is logically scheduling commissioning activities into the master schedule.
- Plan and conduct a commissioning scope meeting and other commissioning meetings.
- Request and review additional information that may be required to perform commissioning tasks including O&M materials and contractor startup and checkout procedures.
- Before startup, gather and review the current control sequences and interlocks and work with contractors and design engineers to obtain, in writing, sufficient clarity to be able to write testing procedures.

EPA Ecosystems Research Division, *Athens, GA*

- Review normal contractor submittals that apply to systems being commissioned for compliance with commissioning needs, concurrent with the A/E reviews.
- Assemble and distribute pre-functional tests and checklists.
- Review startup and initial systems checkout plans developed by the contractors and CM.
- May assist with problem solving, non-conformance, or deficiencies, but ultimately that responsibility resides with the construction manager and the A/E.
- Perform site visits to observe component and system installations. Attend selected planning and job site meetings to obtain information on construction progress. Review construction-meeting minutes for revisions/substitutions related to the commissioning process.
- Review pre-functional tests and checklist completion by reviewing completed reports and by selected site observation and spot-checking.
- Review TAB execution plan. Assist with TAB functions and coordination.
- Review system balancing by reviewing completed reports and by randomly selected site observations.
- With necessary assistance and review from installing contractors, develop general functional performance test procedures (FC) for equipment and systems to be commissioned. This may include BAS system testing and trending or manual functional testing. Submit to CM for review.
- Review functional performance trend logs and monitoring data to verify performance.
- Coordinate and witness manual functional performance tests performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved.
- Maintain a master deficiency and resolution log and a separate testing record (commissioning action list). Provide the CM with written interim reports and test results including recommended actions.
- Assist with scheduling and training the EPA's operating personnel.
- Provide a final commissioning report.
- Coordinate required seasonal or deferred testing and deficiency corrections.

Construction Manager (CM)

- Facilitate the coordination of the commissioning work and ensure that commissioning activities are being logically scheduled into the master schedule well in advance.
- Review and distribute the final commissioning master plan to subs.
- Perform the normal review of contractor submittals.
- Assure the team is furnished with a copy of all construction documents, addenda, change orders, approved submittals, record drawings, and shop drawings related to equipment to be commissioned.
- Assure all equipment submitted has unique identifiers for tracking.
- Prior to testing, review the functional performance test procedures distributed by the contractor.
- When necessary, observe and witness pre-functional checklists, startup, and functional testing of selected equipment. Sign off on all pre-functional checklists.
- Review commissioning progress and deficiency reports.
- Coordinate the resolution of non-compliance and design deficiencies identified in all phases of commissioning.
- Coordinate and schedule the training of EPA personnel.
- Include the cost of commissioning in the total contract price.
- In each purchase order or subcontract, include written requirements for submittal data, O&M data, commissioning tasks, resource requirements, and training.
- Ensure that all subs execute their commissioning responsibilities according to the contract documents and schedule.
- Ensure that all subs provide the necessary tools and resources to complete commissioning.
- Attend a commissioning scope meeting and other necessary meetings scheduled by the CxA to facilitate the commissioning process.
- Prepare O&M manuals according to the contract documents, including clarifying and updating the original sequence of operation to record conditions.

Contractors

- Complete contract work according to the construction schedule.
- Provide dedicated personnel required to complete the commissioning activities.
- Include and identify commissioning requirements in the bid and in the work plan.
- Prepare detailed testing procedures for each item and equipment being commissioned.
- Update the commissioning team with changes in installations due to field conditions.
- Provide all documentation required for completion of the commissioning process including submittals, O&M materials, startup and checkout procedures.
- Identify, document, and correct any deficiencies found during functional testing and immediately report to the CM any deviation from the schedule that will impact the commissioning process.
- Identify and correct any deficiencies found during construction.
- Complete pre-functional tests. Complete and sign off checklists provided by the CxA.
- Provide start-up plans and start equipment and systems.
- Coordinate and assist vendor start-up.
- Complete functional testing. Complete and sign off checklists provided by the CxA.
- Identify, document, and correct any deficiencies found during functional testing. Identify and immediately report to the CM any deviation from the schedule that will impact the commissioning process.
- Provide TAB execution plan. Assist with TAB functions and coordination.
- Activate and manipulate the systems and equipment to facilitate the Cx process.
- Maintain updated record documents.
- Coordinate and assist the ATC contractors.
- Provide all tools and instruments required for the Cx process.
- Assist with maintaining the master deficiency and resolution log.
- Assist CxA in finalizing the commissioning document.
- Conduct training of EPA personnel.

- Provide required seasonal or deferred testing and deficiency corrections. Document testing requirements and responsibilities.
- Provide warranty service as outlined in contract documents.

EPA

- Manage the contracts of the A/E, CxA, and CM.
- Review the pre-functional tests and checklists in a timely manner and provide feed-back to the commissioning team.
- Arrange for facility operating and maintenance personnel to attend various field commissioning activities and training sessions. Personnel attending training should have a basic knowledge of the system they are being trained on.
- Notify the CM and CxA of any items outside the initial scope of work that impact the commissioning activities or schedule.
- Review and sign off on the commissioning turnover packages delivered to the EPA prior to substantial completion of the project.
- Provide all requested submittal data, including detailed startup procedures and specific responsibilities of the EPA, to keep warranties in force.
- Assist in equipment start up and testing per agreements with the CM and subcontractors.
- Verify, through vendors that supply products to the EPA, that the designer has specified the newest, most updated equipment reasonable for this project's scope and budget.
- Provide information requested by the CxA regarding equipment sequence of operation and testing procedures.
- Review test procedures for equipment installed by factory representatives.

EPA Environmental Effects Research Laboratory, *Narragansett, RI*

commissioning process

The EPA mandates commissioning for all new building construction greater than 20,000 square feet. Re-commissioning and retro-commissioning are a major component of the EPA's Energy Conservation Program, ConserveE. Energy Audits are required for 25% of the EPA's "covered facilities" each year per EISA, with follow-up commissioning activities where applicable.

The process begins with the definition of the EPA's and facility users' functional and operational requirements. The EPA documents and conveys these requirements and the vision for the facility in each design consultant's contract and in the Commissioning Authority contract. Additionally, the EPA clearly defines the commissioning roles and scope for all members of the design and construction teams in each design consultant's contract; the construction manager's contract; the general conditions of the specifications; and each division of the specifications covering work to be commissioned and/or for which the supplier's support is required. The integrated commissioning process should include the distinct phases outlined below:

Pre-design Phase
Design Phase
Bidding/Contract Negotiation Phase
Construction Phase
Field Verification
Functional Verification
Performance Verification
Documentation
O&M Staff Training and Documentation
Warranty Review and Seasonal Testing

Selection of Commissioning Authority

Commissioning firms that perform work for the EPA should have the expertise, experience, and staff required by the size and complexity of the project. The firms should also be capable of providing onsite personnel within a required time frame. Selection requirements include the following:

- Minimum of five years experience in building commissioning.
- A registered professional engineer on staff who will be directly involved in commissioning activities.
- Experienced control technicians and test and balance technicians available for mechanical systems commissioning.
- Personnel available who are experienced in the type of system being commissioned.
- Experience in field engineering such as remote monitoring or the field troubleshooting of HVAC systems or energy conservation retrofits and programs.
- Involvement in the professional associations related to commissioning.
- Continuing education in commissioning, including staff attendance at seminars and other training sessions.

General Commissioning

Commissioning is a well-planned, documented, and managed approach to the start-up and turnover of facilities, systems, and equipment to the end-user that results in a safe and functional system that meets established design requirements and end-user expectations for quality.

The commissioning effort results in a turnover package. Acceptance of this turnover package marks the point at which the EPA facility/maintenance team takes ownership of the building. Commissioning documents are intended to verify proper installation, operation at start-up, functional performance, and turnover of facilities, systems, and equipment. The documents are produced by the commissioning team/Commissioning Authority and coordinated with the A/E firm, vendors, construction manager, contractors, and the EPA. Good Engineering Practices (GEP) require that these documents be produced in a timely fashion, are well organized, easily accessible, and properly witnessed/authorized. Attachment 2 of this document provides examples and expectations of commissioning documentation deliverables. These deliverables are collected by the CxA and included in the final turnover package or commissioning summary/final report.

Pre-Design Phase

The objectives of this phase are to document the EPA's vision, requirements, and future expectations for the facility, select the Commissioning Authority, document the initial Design Intent, and begin development of the commissioning plan. The roles and responsibilities of the EPA project manager, design team, the Commissioning Authority, and contractors must be defined for the commissioning process.

During pre-design, the commissioning team should include the EPA project manager, the Commissioning Authority, and the design team. The main commissioning tasks of the pre-design phase include:

- The EPA project manager sends out requests for qualifications for commissioning services, develops the scope of the commissioning effort, and selects a Commissioning Authority and design team.
- The CxA assembles the commissioning team and drafts a design phase commissioning plan.
- The CxA recommends the commissioning roles and scope for all members of the design and construction teams.
- The CxA reviews the Design Intent for clarity and completeness.
- The CxA delivers a draft design phase commissioning plan and comments on the Design Intent document.

The most important components of this early phase of the project are the Design Intent and the Basis of Design (BoD) documents. The Design Intent is the EPA's intention and expectation of the design and operations of the building. As the criterion for correct building operation, the Design Intent may include only major building systems, or it may include a description of correct operation for everything in the building from power quality to cabinet latches. Regardless of what the document includes, it is architectural in origin, having been developed in association with the project design team. The document is performance-based and concentrates on what the occupants need instead of focusing on how the design team will provide it. The Design Intent, once complete, is then turned over to the A/E design team. It has the responsibility to develop the BoD—the primary document that translates the EPA's needs into building components such as occupancy type, room size, population, air quality, etc. The design team will produce design documents based on the BoD.

The job of the CxA is to assure that components have been supplied and installed correctly according to the bid documents, and to assure that the occupants' needs are met as described in the Design Intent. Therefore, the CxA needs both the Design Intent, based on the architect's knowledge of the occupants' needs, and the design itself showing the specified solution.

EPA Environmental Effects Research Laboratory, *Narragansett, RI*

When the Design Intent is presented to the construction team, it should be accompanied by the Basis of Design. The Basis of Design explains why the design team chose certain systems and space arrangements to meet the needs of the occupants. The most basic inclusion in the Design Intent is the general description of the building type (for example, prison, hospital, classroom, geriatric office, etc.). The Design Intent also includes details such as the occupant's age group, particular needs with regard to air quality, outside air volume, occupant load, and pattern of occupancy. The BoD describes the actual technical approach planned for the project as well as the actual design parameters to be used.

Design Phase

The goals of commissioning during the design phase are to ensure that the concepts for building systems developed during pre-design are included in subsequent design phases; that the design record document is updated; and that commissioning is adequately reflected in the contract documents. During the design phase, there are four primary commissioning activities: developing the Basis of Design and expanding the Design Intent as necessary; performing commissioning-focused design review(s); expanding and modifying the commissioning plan to include the construction phase; and developing commissioning specifications for the construction phase. The main design phase commissioning tasks are outlined below:

- The design team develops the Basis of Design document. The CxA reviews it for clarity, completeness, constructability, and compliance with the EPA's Design Intent. In addition, all changes to the initial Design Intent must be documented, reviewed, and approved by the Commissioning Authority and the EPA.
- The CxA attends selected design team meetings and formally reviews and comments on the design at 15 percent, 35 percent, 65 percent and 100 percent stages of development. These design reviews should address potential system performance problems, energy-efficiency improvements, indoor environmental quality issues, operation and maintenance issues, and other issues. The Commissioning Authority ensures that the design meets the original Design Intent.
- The CxA makes recommendations to facilitate commissioning and improve building performance.

- The CxA, in cooperation with the A/E team, develops detailed commissioning specifications that the design team includes in the final contract document. These specifications detail the commissioning process and the scope of work for all participants including contractors and vendors. The specifications comprise requirements for which the contractor is responsible including equipment installation and start-up, documentation, and functional testing. These specifications should be included in the appropriate division as determined by the EPA. Division 1 sections that would be modified to include information about commissioning include the following (actual numerical designations may vary slightly):

  01011—Summary of the Project
  01030—Alternates
  01310—Construction Progress Schedules
  01330—Submittal Procedures
  01400—Quality Requirements
  01730—Operation and Maintenance Data
  01770—Closeout Procedures

  Division 15 sections include the following:
  15000—General Provisions/Testing and Balancing
  15990—Testing, Adjusting, and Balancing
  16000—General Provisions

- While writing the specifications for commissioning, the CxA develops a preliminary commissioning plan. This plan becomes a scope of work that names actual components and systems in the design documents. The CxA develops procedures for each of the systems to be commissioned. This interim plan should be incorporated into the specifications to give contractors the best possible idea of their part in the process. In addition, the CxA recommends enhanced language regarding training, documentation, installation, and system checkout for inclusion in non-commissioning sections of the specifications.
- The CxA delivers regular commissioning progress reports, comments, and recommendations from design reviews to the EPA project manager. The CxA reviews updates of the design records and updates the initial construction phase commissioning plan, and commissioning specifications. The commissioning provider compiles and updates the design records as design progresses.

- The CxA should coordinate this review with any design review the EPA may perform. Generally, reviews performed by the design review group are limited to programmatic and code compliance and constructability issues. The review performed by the CxA should, at a minimum, determine that the documents are consistent with the Design Intent; specify commissionable systems; include inspection and testing details; include equipment parameters that can be verified; incorporate a layout that allows testing and maintenance; and fully describe the commissioning process for the contractors.

The EPA project manager monitors the design phase process and makes certain that procedures are in place so issues the Commissioning Authority raises are reviewed and the team comes to a consensus. If a consensus cannot be reached on an issue, the team should document the issue, and the EPA should provide a decision and direction in consultation with the appropriate design professional.

Bidding/Contract Negotiation Phase

The selection of the contractor is a brief but important time in the commissioning process since it is vital that they cooperate in the commissioning process if the team is to reach the goal of a quality building. Construction personnel perform the inspection and testing required by the CxA.

As the bidders/proposers prepare their bids/proposals, there will be questions about their roles in commissioning. The CxA should answer these questions, either at a pre-bid/pre-proposal conference, in writing, or both. In addition to answering contractor questions, the CxA may need to answer questions for the design team. This is especially true if the bids/proposals come in over the cost estimate. The CxA may be called upon to evaluate the savings in commissioning costs that should result from cutting out portions of the project to make the required budget.

When the pre-bid/pre-proposal conference is organized, the CxA should be placed on the agenda to present a brief overview of the commissioning process and answer specific questions posed by the contractors. The questions and answers that come out of this conference, including those related to commissioning, should be recorded in the minutes and issued in writing to all bidders/proposers as an addendum. The CxA should provide answers to commissioning questions to the EPA's project manager. Subsequent addenda will answer questions posed to the EPA and design team after the pre-bid/pre-proposal conference; however, they may or may not include commissioning questions. All commissioning questions posed by the contractor should be routed through the EPA and then to the CxA to assure that each response is sent in an identical form to all contractors and members of the design team. The CxA should review any addendum to confirm that revised drawings and specifications do not reduce the commissioning requirements or capabilities. The CxA should stay alert to any changes in construction time as related to addenda. If there are significant changes in the project that will affect the time for CxA services, the CxA should make sure adequate time is added to the contractor's construction time in the addenda to allow for commissioning.

Construction Phase

The main construction phase commissioning tasks for the CxA are listed below:

- The CxA updates the construction phase commissioning plan that includes a list of all systems and specific equipment and components to be commissioned; the process to be followed; communications, reporting and documentation protocols; and an estimated schedule for the commissioning process. The final draft of the commissioning plan is completed during the early stages of construction after all equipment submittals have been approved and before equipment has arrived on the site. The plan starts with the requirements on a system-by-system basis and provides more detail based on the actual design and the equipment ordered. The commissioning plan developed at this point has detailed information on the support required from the contractor and responsible subcontractor personnel.
- The CxA coordinates a construction phase commissioning kickoff meeting that includes the EPA project manager, the construction manager, design team, CxA, respective representatives from the general contractor, and mechanical, electrical, controls, and testing and balancing (TAB) subcontractors. At this meeting, the Commissioning Authority outlines the roles and responsibilities of each project team member; specifies procedures for documenting commissioning activities and resolving issues; and reviews the preliminary construction phase commissioning plan and schedule.
- The CxA attends periodic planning meetings to update the parties involved in commissioning. During the initial stages of construction, the commissioning provider may attend regular construction meetings and hold a line item on the agenda. Later in construction, the commissioning provider may coordinate entire meetings devoted to commissioning issues.
- The CxA develops and keeps a record of issues and findings throughout the construction phase commissioning process that require further attention, tracking, or correction.
- The CxA reviews and comments on contractor submittals of equipment to be commissioned during the normal submittal review process and forwards them to the EPA project manager and designer.
- The CxA should assist the EPA project manager in monitoring the development of coordination drawings to ensure interface between trades.
- The CxA reviews the O&M manual to ensure that it complies with the specifications, is complete, clear, well organized, and accessible to the O&M staff.
- The CxA visits the construction site periodically, notes any conditions that might affect system performance or operation, and provides construction observation reports.

Manchester Regional Laboratory, *Port Orchard, WA*

During the early stages of construction, the CxA continues to answer questions for the construction manager (CM) and verify that commissioning is being integrated into the construction process. The best venue for this is the preconstruction meeting.

The first item of discussion is the schedule. The construction schedule is the key document that allows the EPA to track the construction process. Developing the schedule involves two tasks: 1) placing commissioning milestones on the construction schedule, and 2) including the contractor's commissioning activities in the schedule of values. The CxA works with the CM and, if necessary, the subcontractors to discuss phasing and timing of commissioning. The CM is required to integrate the information into the overall schedule of the project. In this way, all subcontractors are given additional notice about the requirement for commissioning. When the schedules are submitted, copies are routed to the CxA for review with regard to commissioning milestones. These milestones, shown on the tentative schedule of commissioning activities, should be integrated into the overall schedule by the time it is submitted for approval. As other milestones are revised, the commissioning schedule should be revised accordingly.

As the CM delivers equipment submittals to the design engineer, the EPA project manager should route copies of the approved submittals to the CxA for information only. The CxA reviews and comments to the EPA if there is anything in the submittals that appears wrong. The CxA should make sure that any submittal requirements for items key to commissioning are not left off contractor submittals.

Commissioning procedures include static inspection, startup, and functional test descriptions. The CxA writes and assembles these procedures as part of the commissioning plan as equipment information is available from submittals. Completed documents should be submitted to the EPA's project manager and the designer for approval, and then to the CM for scheduling.

The final draft of the commissioning plan is completed during the early stages of construction after all equipment submittals have been approved and before equipment has arrived on the site. It starts with the requirements on a system-by-system basis and provides more detail based on the actual design and the equipment ordered. The commissioning plan developed at this point has detailed information on the support required from contractor personnel. Specifically, each inspection and test should be annotated to show the responsible subcontractor. This document will be used by the CM to schedule personnel to assist the CxA in testing and inspection.

When the commissioning plan is completed, equipment is ordered, and the building foundation and framing has begun, the static inspection phase of commissioning begins. This phase lays the groundwork for equipment startup by confirming that it is installed in such a manner that it can function safely and effectively. This includes verifying items in the list below, among other things:

- Equipment location: Are units located according to plans and practical requirements? For example, are the air-handling units positioned to allow full-access door openings for maintenance?
- Installation of instrumentation: Are installations performed according to manufacturers' requirements (such as laminar flow for flow sensing devices) and according to engineering requirements (such as duct pressure sensors located 3/4 of the distance to the furthest point in a VAV duct system)?
- Drain piping: Are drains sloped as specified and have pipes been pressure tested?
- Sheaves: Are all sheaves aligned properly?
- Connection to power and other utilities: Have utility connections been verified?
- Pipe and duct support: Are these items properly suspended for safety and function?

The CxA provides checklists to construction personnel to carry out these inspections. These checklists incorporate manufacturers' requirements and other basic steps that typically would be done even without the commissioning process and, therefore, should not take a great deal more time than the normal checkout procedure. As the CM submits completed checklists, the CxA spot-checks the forms. If the checklists have not been completed accurately, shortcomings will be reported prior to the start of functional performance tests (FPTs). If FPTs are cancelled and rescheduled, the CM is responsible for the cost of repeat testing (an important notice to be included in the specifications).

Examples of inspection activities are as follows:

Piping and HVAC Ductwork

- During construction, piping and ductwork should be inspected for correct installation and should be pressure tested.
- Items affecting maintenance, such as valve locations, damper access panels, plumbing cleanout access, and sloped piping for drainage, etc., should be checked during construction inspections.
- Domestic water and sanitary sewer piping testing is a contractor quality assurance requirement — as well as a code requirement — and should be witnessed by the EPA's representative, the architect, or the CxA.
- Low-pressure (less than three inches static pressure water gauge) ductwork need not be pressure tested. However, all ductwork should be inspected visually before insulation for correct joining and supports.
- Testing, adjusting, and balancing (TAB) of air and water systems should have been preliminarily performed and ready for startup of the HVAC equipment. CxA to verify.

Air Handling Units and Other Major HVAC Equipment

- Air handling units (AHUs), make-up air units, rooftop heating and cooling units, and similar equipment should be inspected for mechanical items such as properly functioning case drains, filter seals, maintenance access, general air tightness, and vibration isolator supports.
- Control devices, such as sensors and actuators, should be verified as complete according to the building automation system (BAS) points list and control diagrams. These devices should be correctly located and completely and soundly installed.
- All electrical wiring should be verified as installed properly, in conduit, terminated, grounded, and tested to confirm power and correct polarity (for motor rotation).
- HVAC piping should be inspected for air handling units including coil connections, control valve locations, balance valves and test ports, bypasses, drain pans and traps, and maintenance isolation valves.
- Lubrication points for fan and motor bearings, as well as all movable supports, should be checked and mounting fasteners confirmed.

Building Automation System (BAS) Controls

- The controls contractor should perform a complete point-to-point checkout of all control devices throughout the building. Checkout confirms that the engineer's point list is installed as designed. CxA to validate.
- For laboratories or other critical environments as defined by the EPA, all input and output devices in the critical zones should be calibrated to NIST (National Institute of Standards and Technology) traceable standard at the job site. Critical devices are defined in the contract documents in the I/O summaries or I/O list. Factory calibrations are not acceptable. The CxA must certify that this has taken place prior to functional performance testing.

Electrical Systems

- During construction, power feeder cables should be tested for proper insulation and dryness. An EPA representative or CxA should monitor the tests.
- Switchgear, panel-boards, etc., should be inspected for proper connections and grounding.
- Authorized testing companies should certify building electrical grounding and lightning protection systems.

Fire Protection and Life Safety Systems

- Fire service water-line piping should be flushed and tested; NFPA (National Fire Protection Association) certificate is required.
- Above-ground fire protection piping should be flushed and tested, preferably per floor. Local fire officials normally witness this testing. NFPA certificate is required.
- Smoke and heat detection sensors at air moving equipment should be checked and verified for proper installation.

Field Verification

The field verification phase of commissioning starts when the commissioning plan is completed, equipment is ordered, and construction begins. The field verification phase lays the foundation for equipment startup by confirming that installed equipment can function safely and effectively.

The CxA develops and provides construction checklists for installation, startup, and initial checkout of the equipment and systems to the contractor for execution. These checklists also incorporate manufacturers' requirements. The CxA witnesses some of the start-up execution and spot-checks selected items on the checklist prior to functional testing. The contractor executes construction checklists provided by the CxA and equipment manufacturer and submits them to the CxA for review before functional testing begins.

Equipment is started up for the first time with required factory representatives in attendance. The equipment should be tested at all required speeds and preliminary programming should be completed as required to allow subsequent safe and easy starting. On most projects, the main issues that historically arise during equipment startup are related to control software for the temperature control system.

Functional Checklist/Performance Testing

Functional checklist/performance testing is conducted to verify that the performance of all integrated systems meets the specified objectives defined in the Design Intent. Functional performance testing ensures that equipment and systems are installed correctly, tested, and adjusted so they operate efficiently and according to Design Intent under a variety of conditions. This testing is intended to document the completion and performance of all components, equipment, and systems.

Functional performance testing should progress from functional verification to performance verification in sequence, from individual equipment or components through subsystem operation to complete systems. At the end of the testing, every mode of building and system operation, all system equipment, system interfaces, and every item in the control sequence description is proven operational under all normal operational modes including load, in all seasons, and under abnormal or emergency conditions.

Functional Verification

- The CxA develops written test procedures, manages, witnesses, and documents the functional tests with the hands-on execution of the test procedures typically carried out by subcontractors, particularly the controls contractor.
- Acceptable performance is reached when equipment or systems meet specified design parameters under full-load and part-load conditions during all modes of operation, as described in the commissioning test requirements of the specifications and commissioning plan (some testing will be completed by monitoring system operation over time through the building automation system or data loggers a few weeks after occupancy).
- The CxA does not re-test systems that have been tested and approved by regulatory authorities. The CxA prepares test plans, assists with execution, and documents tests of commissioned equipment overseen by regulatory authorities.
- The CxA should assist in programming the building automation system (BAS) to include the trend logging of a selected group of key performance indicators. These indicators include temperatures and pressures for boiler and chiller operations; duct pressures; outside airflows; some typical variable air volume terminals operating parameters; and unitary equipment performance parameters.

Performance Verification

After equipment has been proved at startup, to confirm that the pieces work together, the Commissioning Authority conducts functional performance tests that are the heart of the commissioning process.

- Functional tests include checking BAS parameters such as programmed addresses, sensor calibration factors, occupied/unoccupied programming, and trend logging. Programming charts, sequences of operation, block wiring diagrams, and wiring termination diagrams should be included in the report. All BAS tuning variables, such as response times, damping variables, delays, and interlocks, should be included in the report. In laboratory and other critical facilities, the control input and output points are calibrated and loop checked (inputs will be simulated with signal generators).
- During the completion of functional performance testing, the CxA assists in the programming of the BAS to include the trend-logging of a selected group of key performance indicators. These indicators usually include temperatures and pressures for boiler and chiller operations, duct pressures, outside airflows, operating parameters for some typical variable air volume (VAV) boxes, and performance parameters for unitary equipment. Some specifications note that temporary flow-monitoring equipment be installed to verify system operation. The EPA project manager should consider making the flow-monitoring equipment permanent and include it as part of the project so the operations and maintenance staff can continue to use the instrumentation.

- The subcontractor's testing, adjusting, and balancing report is checked for accuracy by sampling the report data. If a substantial failure rate is encountered, all failures should be corrected and a different sample chosen for a repeat test. The EPA project manager may elect to have the CxA perform TAB.
- As functional performance tests proceed, the CxA may find a number of items that do not appear to work as intended. The Commissioning Authority needs to perform a varying amount of retesting because of system and equipment failures during the initial testing. The amount of retesting that is paid for by the EPA and the amount that is passed back to the contractor should be very clearly spelled out in the construction contract.
- The Commissioning Authority verifies the accuracy of facility record drawings.

Final and Post Acceptance Phase

When the requirements of the contract documents and commissioning plan have been completed and satisfactorily documented, and any additional required documentation has been completed, submitted to the design professionals, and accepted, the CxA should recommend final acceptance of the building and all building systems. The recommendation is issued subject to any outstanding issues or deficiencies that cannot be resolved until a future date.

The post-acceptance phase is an important step in ensuring the effective, ongoing functioning of a facility's building systems. As use and function of facilities change, the building systems need to be adapted to the changing occupancy requirements. It is appropriate to maintain a history of the facility, record changes, and verify their effect on the previously commissioned systems.

The post-acceptance phase includes the completion of any outstanding functional performance tests; a post-construction review, at a set or variable period after construction; evaluation and verification that the Design Intent of the building is still being met; and ongoing monitoring.

Post-acceptance commissioning is the continued adjustment, optimization, and modification of the HVAC system to meet specified requirements. It includes updating documentation to reflect minor set point adjustments; system maintenance and calibration; major system modifications; and ongoing training of operations and maintenance personnel. The objective of post-acceptance commissioning is to maintain the performance of the building systems throughout the useful life of the facility in accordance with the current Design Intent.

A post-construction review should be scheduled a set number of years after completion of construction or in response to significant changes in the facility's structure, equipment, or use. As-built documents must be revised to reflect modifications made to any part of the facility or the building systems. Any change in usage, installed equipment, loads, or occupancy must be carefully

monitored and documented, as should any system servicing and maintenance problems. If the variations are significant enough to warrant a re-commissioning of the individual systems, or as a method of continued maintenance, an earlier review should be conducted.

Documentation

The Commissioning Authority develops the following documentation during the construction phase:

- Updated construction commissioning plan
- Updated commissioning schedule
- Minutes from commissioning meetings
- Commissioning progress reports
- Reports of submittal reviews
- Updates to the commissioning issues
- Construction checklists and functional test forms
- Report of training completion
- Report of O&M manual review
- Systems manual
- Commissioning records

Warrantee Phase

At the completion of training and all other work required by the contract documents, the building will be occupied. There should be a specific notice in the specifications indicating to the CM that the successful completion of commissioning is a requirement for the issuance of the final certificate for payment. Issues may arise during the one-year warranty period, but if the CxA process has been followed, the issues should be minor and readily handled by the O&M staff armed with documentation and training. The commissioned building should provide the working environment required for the occupants, and the O&M staff can concentrate on establishing an effective preventive maintenance program that should work for the life of the building.

Seasonal Testing

Depending on the overall weather extremes in the region of construction, it is likely that certain parts of the building mechanical system cannot be adequately tested in the season of the completion. For instance, testing of a boiler system might be difficult in the summer, and testing of a chiller and cooling tower might be difficult in the winter. Checking the outside air percentage is much easier when there is a substantial difference in temperature between the outside air and the return air.

Robert S. Kerr Environmental Research Center, *Ada, OK*

For this reason, commissioning plans should include off-season testing to allow certain equipment to be tested under the most appropriate conditions. This requirement must be clearly spelled out in the specifications because it will require some contractor personnel to return to the site after the project is completed. It is also necessary to withhold money for this activity in addition to that usually withheld for warranty items. It is also recommended to test the systems during the shoulder seasons (spring/fall). Items to look for include proper dehumidification sequences and partial load performance of mechanical systems.

Continued CxA Contact

As described in previous sections, the CxA is involved throughout the course of the project and will have gained valuable knowledge regarding the systems and their operating characteristics. The CxA's contract, at a minimum, should provide the EPA with the ability to engage the CxA for occasional, informal consultations throughout the warranty period or during approximately the first year of building operation.

To ensure the ability of the O&M staff to operate the building in the first year of operation, the EPA project manager arranges for periodic monthly training sessions that the CxA attends in order to consult with the staff. Off-season testing is coordinated with these site visits.

Commissioning for LEED Building Rating

LEED for New Construction

The following section includes general requirements found in the current "LEED for New Construction 2.2 Reference Guide" as well as the future "LEED for New Construction 2009." "LEED NC 2009" is expected to be adopted in the first quarter of 2009. For detailed requirements and expectations, refer to currently adopted LEED reference guidelines.

Fundamental building systems commissioning is a prerequisite for LEED-NC building rating and requires having a contract in place to implement the following fundamental best practice commissioning procedures:

- Engage a CxA prior to the start of design.
- Engage a commissioning team that does not include individuals directly responsible for project design or construction management.

- Review the Design Intent and the Basis of Design documents.
- Incorporate commissioning requirements into the construction documents.
- Develop and implement a commissioning plan.
- Verify installation, functional performance, training, and operation and maintenance documentation.
- Complete a summary commissioning report.

Additional system commissioning or enhanced commissioning allocates one credit point (two credit points in future LEED NC 2009 requirements) in addition to the fundamental building commissioning prerequisite. Prior to the start of the construction phase, designate an independent Commissioning Authority (CxA) to lead, review, and oversee the completion of all commissioning process activities. The CxA shall meet the following requirements:

- Have documented Commissioning Authority experience in at least two building projects.
- Be independent of the work of design and construction.
- Not be an employee of the design firm, though he/she may be contracted through them.
- Not be an employee of, or contracted through, a contractor or construction manager holding construction contracts.
- Can be a qualified employee or consultant of the EPA.

The CxA shall, at a minimum, perform the following tasks:

- Independent of the design team, conduct a review of the design prior to the construction documents phase and report results, findings, and recommendations directly to the EPA.
- Conduct a review of the construction documents near their completion and prior to issuing the contract documents for construction.
- Conduct, at a minimum, one commissioning review of the EPA's Design Intent, Basis of Design (BoD), and A/E design documents prior to mid-construction documents phase and back-check the review comments in the subsequent design submission.
- Review the contractor submittals relative to systems being commissioned for compliance with project requirements and Basis of Design.
- Provide the EPA with a single manual that contains the information required for re-commissioning building systems.
- Have a contract in place to review building operation with O&M staff and occupants, including a plan for resolving outstanding commissioning-related issues, within 10 months after substantial completion.

LEED for Existing Buildings

The following section includes general requirements found in the current "LEED for Existing Buildings Reference Guide." For detailed requirements and expectations, refer to currently adopted LEED reference guidelines.

The purpose for commissioning an existing building is to verify and ensure that the fundamental building elements and systems are installed, calibrated, and are operating as intended to meet the current needs of the building and its occupants. Comprehensive existing building commissioning includes the following procedures:

- Develop a comprehensive building operation plan that meets the requirements of the building's current usage. The plan should address the heating, cooling, humidity control, lighting, and safety systems as well as the building automation controls.
- Develop and implement a building commissioning plan to carry out the testing of these systems and verify they are operating in accordance with specifications of the building operation plan.
- Repair or upgrade all systems or equipment that are not working and then re-test to verify their operation in accordance with the specifications of the building operation plan.

In lieu of performing these tasks, develop a one- to five- year plan for continuous improvement of these aspects of commissioning until all are completed. Demonstrate continuous improvements on a yearly basis with all low-cost and no-cost measures implemented within the first two years of the implementation program.

EPA Property (Owned and Leased) Commissioning

The commissioning guidelines and requirements for the selection of a Commissioning Authority apply to properties owned by the EPA, as well as properties leased by the EPA. The following additional requirements are conveyed to the developer constructing and/or leasing property to EPA:

- While the developer follows EPA commissioning guidelines, the developer (not the EPA representative) is responsible for selecting the Commissioning Authority and all aspects of the commissioning process, commissioning matrix, and LEED credits for leased building commissioning.
- The Commissioning Authority delivers regular commissioning progress reports, comments, and recommendations directly to the EPA representative.
- If the Commissioning Authority finds any items during performance tests that do not appear to work as intended, the EPA will provide a decision and direction to the developer.
- Acceptance of the Commissioning Authority's findings, determinations, and reports will be used as a basis for the EPA's acceptance of the building.

commissioning final report

When training is complete, the Commissioning Authority should have completed the commissioning final report. This report should contain copies of the following:

Design Intent Document
Basis of Design Document
Complete pre-functional checklists
Complete functional checklists
TAB reports
System schematics
Control strategies and set points
Deficiency log
Guidelines for energy accounting

The commissioning final report, the TAB report, the O&M manuals, and the record drawings and specifications form the documentation that will be left with the O&M staff. Additional information on building controls including block-wiring diagrams, as-built control diagrams, and sequences of operation will also be included in either the commissioning final report or the O&M manual.

retro-commissioning (RCx)

Retro-Commissioning Introduction

Retro-commissioning involves a similar process of verifying that installed equipment is operating efficiently and is capable of providing the services necessary to meet the needs of the building's occupants. The process can solve issues of high energy and maintenance costs, occupant complaints, indoor environmental quality, and shorter than expected equipment lives. Retro-commissioning is a systematic investigation process that optimizes building performance by identifying and implementing relatively low-cost operational and maintenance improvements. It is not a substitute for major repair work. Known problems should be repaired before RCx begins. The RCx process not only optimizes how individual equipment and systems operate, but how the systems function together.

Retro-Commissioning Objectives

The RCx process is a project-specific effort. Each project's focus, goals, and the level of rigor depend on the needs of the EPA and occupants, the budget, and the condition of the facility and equipment. RCx most often focuses on dynamic energy-using systems with the goal of reducing energy waste, saving energy costs, and identifying and fixing existing problems. Retro-commissioning accomplishes the following:

- Reduces energy costs and demand.
- Brings equipment to its proper operational state.
- Reduces occupant complaints.
- Improves indoor environmental quality.
- Reduces premature equipment failures.
- Improves facility operation and maintenance procedures.
- Reduces staff time spent on emergency or complaint calls.

In some cases, RCx may be undertaken at the same time as other complementary processes or projects such as major equipment replacements or major retrofits (upgrades).

Retro-Commissioning Process

RCx projects typically occur in four distinct phases: planning, investigation, implementation, and handoff. In some cases the tasks may overlap, occur simultaneously, or be eliminated entirely. Variables that affect the RCx process include the condition of the facility, scope of the project, budget, and availability of in-house expertise. Sometimes the planning phase is completed partially or fully by the EPA or building staff before the RCx service provider is brought on board.

Retro-Commissioning - Planning

The primary tasks for the planning phase are developing internal goals and support for the project; selecting and hiring a RCx service provider; and assembling the team that will see the project through to completion. All of these steps are critical to ensuring a successful RCx project. Major planning phase activities include the following:

Develop Project Objectives:

The RCx process begins by defining project goals in writing and clearly communicating them to the project team. The primary goal is to save costs by improving the operation of the building's energy-using equipment given the current operating requirements, then identifying and eliminating potential indoor environmental quality and occupant complaints. RCx project objectives include the following:

- Obtain and verify cost-effective energy savings. Verification will require limited performance monitoring of selected building systems.
- Identify and recommend improvements to operational strategies and maintenance procedures, focusing on those measures that sustain optimal energy performance and reduce operating costs.
- Identify HVAC-related health and safety issues as they present themselves during the normal course of the RCx work.

When commissioning is specified solely for new equipment, it often stops short of the whole-building RCx process that evaluates how new equipment interfaces with existing systems and their performance. For this reason, retro-commission should include both new and existing equipment.

Develop the Retro-commissioning Plan and Hold a Kickoff Meeting:

After gaining a clear understanding of the project goals, the RCx service provider develops the final RCx work plan with input and review from the EPA. The final work plan usually includes the following:

- General building and contact information (name, address, telephone numbers, etc.)
- Project goals
- Brief building and systems descriptions
- Project scope
- Roles and responsibilities
- Schedule (for primary tasks)
- Documentation request
- Investigation scope and methods
- Implementation phase requirements
- Project hand off

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Retro-Commissioning – Investigation

The primary goals of the investigation phase are to understand how and why building systems are currently operated and maintained; identify issues and potential improvements; and select the most cost-effective "fixes" for implementation. Depending on the scope of the project, this phase may look at all aspects of the current O&M program as well as the management structure, policies, and user requirements that influence it. Tasks during investigation may include interviewing management and building personnel; reviewing current O&M practices and service contracts; spot testing equipment and controls; and trending or electronic data logging of pressures, temperatures, power, air and water flows, and lighting levels and use. A discussion of the major investigation phase activities follows.

Gather and Review Facility Documentation:

The RCx service provider uses building documentation to develop the site assessment forms and the diagnostic and functional test plans that will be required to verify equipment performance. Important documentation categories include the Energy Management Control System (EMCS); operation and maintenance manuals; original Design Intent Documents; equipment lists; and test, adjust and balance (TAB) reports.

Begin Site Assessment and Begin Master List of Potential Improvements:

The goal of the site assessment is to learn how and why building systems and equipment are currently operated and maintained, and to discuss with building staff and occupants what they consider to be the most significant problems. After the site assessment, the RCx service provider begins to develop a list of cost-effective strategies and recommended improvements for optimizing building performance. Some projects may require the RCx service provider to develop a formal site-assessment document that includes a detailed building staff interview regarding operating strategies and an in-depth site survey of equipment condition. Site assessment forms are developed for each system and piece of equipment that is selected for RCx. The site assessment addresses the following major issues:

- Overall building energy use and demand, and areas of highest energy use and demand.
- Current design and operational intent and actual control sequences for each piece of equipment included in the project.
- Equipment nameplate information and maintenance issues (broken dampers, dirty coils, sensor calibration, etc.).
- Current schedules (set point, time-of-day, holiday, lighting, etc.).
- The most severe control and operational problems.
- Location of the most comfort problems or trouble spots in the building.
- Current O&M practices.

The site assessment reveals the best opportunities for optimizing energy-using systems and improving O&M practices. It provides the starting point for evaluating the effectiveness of improvements and O&M activities. It also provides a basis for recommending where diagnostics and testing may be appropriate.

Develop Diagnostic Monitoring and Test Plans:

The site assessment indicated areas where further investigation is needed. The next step is for the RCx service provider to develop the appropriate diagnostic monitoring and test plans that allow him/her to observe temperatures along with critical flows, pressures, speeds, and electrical currents of the system components under typical operating conditions. The RCx service provider analyzes this information and determines whether the systems are operating correctly and in the most efficient manner. Three typical diagnostic methods are energy management control system trend logging, stand-alone portable data logging, and manual functional testing. The RCx service provider and the EPA schedule the implementation of the diagnostic monitoring, testing, and the associated preparatory work. Preparing for monitoring and testing may include checking and calibrating control points such as temperature sensors. If data loggers are used, facility staff should assist in the installation and removal of the loggers, when possible. The trend-logging plan may be carried out by the facility staff, but may require assistance from the controls vendor, particularly on developing, formatting, and downloading computer files for analysis by the RCx service provider. Results from monitoring, via trend logs or data loggers, are provided in annotated graphical or columnar format for reporting purposes.

The retro-commissioning service provider directs the functional performance tests. Facility staff, a control vendor, or other appropriate parties assist with the hands-on operation of the equipment being tested. The RCx service provider documents manual testing and results on the test plan forms that describe the piece of equipment or system and the detailed test procedures.

After diagnostic monitoring and testing are completed, the findings are analyzed and checked against the site-assessment information. Any resulting changes, additional findings, or potential improvements are summarized on a master list. At this point the RCx service provider will estimate the potential savings associated with the findings.

Develop an Initial List of Findings:

The master list is one of the most significant deliverables from the RCx process and ultimately becomes an important decision-making tool for the facility manager and building staff. Every finding from the investigation phase is summarized on the master list. The master list should contain the following categories of information: identifying number, type of equipment, finding description, recommended improvement, estimated energy savings, etc.

After the master list of findings is complete, the RCx service provider assembles an interim report highlighting the process and findings. The interim report is a primary decision-making tool for the EPA project manager and typically contains the master list of the RCx findings, recommended solutions, and a cost/benefit analysis. An implementation plan may also be included depending on the requirements in the RCx scope of work. The methodology for arriving at the costs and benefits or energy cost savings is included along with any engineering calculations. The following are typical deliverables for the investigative phase:

- Short-term diagnostic monitoring and functional test plans.
- The master list of findings and recommendations.
- Completed test and monitoring plans.
- List of repairs, adjustments, and other improvements made during investigation.

Analyze, Prioritize, and Select Repairs and Improvements:

Once the site assessment and diagnostic testing are complete and the master list is finished, the EPA decides which items provide the most benefit and effectively meet the project objectives. If the project is receiving outside funds, the implementation requirements of this funding source must also be considered.

The RCx service provider can assist with this decision-making process by analyzing the opportunities and making recommendations for implementation based on the cost-effectiveness of various improvements.

Retro-Commissioning – Implementation

During the implementation phase, the more complicated and expensive findings that were not rectified during the investigation phase are completed. The following are Implementation phase activities.

Implement Repairs and Improvements:

A primary goal for most retro-commissioning projects is to achieve results by actually implementing the major cost-effective improvements. Functional retesting is performed after implementation.

Verify Results (Re-monitor and Retest):

Once an improvement or "fix" is completed, retest to confirm that the effected equipment is operating properly. This can be done through EMCS trending, manual testing, or data-logging. In some cases, it may be necessary to use a combination of these methods. Retesting might involve manually testing the repaired items such as damper motors or valves to verify that they stroke properly, followed by EMCS trending or data-logging to determine that they are modulating to maintain the desired set-point at the appropriate times. The data is compared to the original, pre-implementation data in order to confirm that the combination of improvements is integrated and has the desired effect for the building.

Retro-Commissioning - Final Report

The RCx service provider produces a final report documenting the process and its findings, and holds a project close-out meeting. Any additional tasks requested by the EPA are also completed at this time.

Final Report:

The EPA may specify what information is included. Ideally, the final report contains:

- Executive summary.
- The retro-commissioning plan.
- The master list of findings with a description of the improvements implemented.
- A cost/benefits analysis and the actual improvement costs.
- A list of capital improvements recommended for further investigation.
- The BAS trending plan and logger diagnostic/monitoring plan and results.
- All completed functional tests and results.
- Recommended frequency of re-commissioning.
- Documentation of strategies adopted to optimize systems operations.
- Updated (or created) building documentation.

The retro-commissioning service provider should either provide training or ensure that the contractor/manufacturer provides adequate training for operating staff, and return to perform deferred testing (seasonal testing).

Update or Create Building Documentation:

Depending on the contract, the RCx service provider may leave the building's O&M staff with a complete package of building documentation in order to extend the benefits of the RCx. The RCx service provider completes the following tasks as appropriate:

- Develop one-line drawing schematics of each system investigated.
- Finalize the O&M plan outline including the examination and enhancement of current maintenance or service contract procedures.
- Develop a list of required O&M documentation and a systems operations manual including full sequences of operation for equipment missing that documentation.
- Develop an energy-efficiency plan.
- Develop guidelines for implementing a preventative maintenance plan.
- Develop a comprehensive training plan or recommendations for appropriate building staff to attend training in general O&M concepts for specific equipment and systems. This will include both building operators and facility managers or EPA project managers.
- Develop guidelines and recommendations for developing an energy accounting and tracking system. Include benchmarks for whole building energy use and primary plant equipment efficiency tracking.
- Develop a list of operational strategies for the EPA to incorporate in the future.
- Develop a re-commissioning schedule and plan.

Continuous commissioning is similar to retro-commissioning and begins by identifying and fixing HVAC and comfort problems in the building. When the continuous commissioning is complete, the team continues to work together to monitor and analyze building performance data provided by permanently installed metering equipment. This process ensures that the savings achieved from the commissioning continue over time.

support programs

Good Engineering Practices (GEP)

Good Engineering Practices are established engineering methods and standards that are applied throughout the project lifecycle in order to deliver appropriate, cost-effective solutions. GEP encompasses the following:

- Design and installation that takes into account safety, health, environmental, ergonomic, operational, maintenance, recognized industry guidance, and statutory requirements.
- Professional and competent project management, engineering design, procurement, construction, installation, and commissioning.
- Appropriate documentation including design concepts, design schematic drawings, Design Intent, Basis of Design, engineering and/or functional requirements specifications (FRS), detailed design specifications (DDS), as-built drawings, test records, maintenance and operation manuals, statutory inspection certificates, etc.

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Triangle Park, NC

Factory Acceptance Testing (FAT)

Factory acceptance testing performed by the manufacturers at their sites will be leveraged whenever possible to support the commissioning activities. The commissioning team (or designees) will review the vendors' factory test plans prior to implementation. The intent of this review is to determine if the test plans and forms can adequately support the commissioning of the equipment/system. Certain test plans and forms, when witnessed by an appropriate representative(s), will reduce redundant testing that may be incurred in the commissioning testing phases. Some examples of factory documentation include the following:

- Factory calibration certificates and documentation (instrument list)
- System overview, P&ID, loop, panel, and wiring drawings (verified to as-built)
- Factory component tagging and wiring verification documentation
- Pressure tests
- Loop check documentation
- Sequence of operation test plans
- Alarm, interlock, and safety test plans
- Application software test plans
- PLC and operator interface terminal (OIT) test plans
- Factory test forms (trial runs)
- Factory test report/close-out

The use of factory testing to support the reduction of field-testing and commissioning testing will be based on the following criteria:

- Determination of those critical functions that can be verified in the factory and have little risk of change during shipment and installation.
- Review and pre-approval of the critical factory test plans and forms by members of the commissioning team prior to their use in the factory.
- A representative of the commissioning and project team witnessing critical factory test executions.

Site Acceptance Testing (SAT)

SAT is a milestone activity in the delivery process of equipment and systems. The SAT warrants that the manufacturer has delivered the subject equipment/system and it operates and performs after breakdown, transport, and installation at the end-user location in the same manner as was established during the FAT. The EPA may opt to eliminate the SAT requirement for equipment and systems that will be moved straight into commissioning upon installation.

EPA Andrew W. Breidenbach Environmental Research Center, *Cincinnati, OH*

Preventive Operations and Maintenance (PO&M)

In order to protect, for example, the energy management goals of the EPA after building turnover, the CxA helps the EPA develop a customized preventive operations and maintenance program. A preventive maintenance (PM) plan is a vital part of any preventive operations and maintenance program (PO&M Program) that can lead to energy efficient building operation. The EPA can benefit from implementing a PM plan to help prevent performance degradation by tracking the performance of every piece of major equipment.

Without question, equipment and system performance will degrade over time. Below are some typical reasons for performance degradation:

- Schedule changes that are intended to be temporary often become permanent.
- Tenants, facility managers, custodial staff, service contractors, controls contractors, and others change energy management systems and equipment settings without documenting the changes.
- Power outages may alter schedules for time clocks and energy management systems.
- Renovations, additions, and build-outs may not consider operational issues.
- Efforts to ensure efficient equipment operation may be partially wasted if the equipment runs during hours when it is not needed.

The goal of preventive maintenance is to improve equipment reliability and extend equipment life. A functional operational and maintenance plan completes the picture by optimizing facility operations to provide significant energy savings and comfort benefits. A good O&M plan is a risk reduction strategy helping to insure that equipment runs efficiently, functions properly, and does not fail prematurely. It can even lengthen the life of equipment.

The CxA should provide the EPA with a program that contains not only a detailed PM plan, but also a functional O&M plan. This plan combines the elements of the basic O&M plan with details that provide for equipment to be operated in the most energy efficient manner. PO&M programs differ from typical PM plans in that they call for periodic checks for operational and control issues. These periodic checks also call for investigation of issues that affect efficiency. Examples include questions of when and how long equipment operates and what causes a piece of equipment to cycle on or off, or fail.

O&M Staff Training and Documentation

Poor equipment maintenance adversely affects its performance. Likewise, poor operational practices can increase the amount of maintenance required to keep equipment running. The best preventive maintenance and operational programs will include adequate training of O&M personnel that will enable them to optimize building operations.

Once O&M personnel reach a basic skill level, the CxA becomes a valuable training source not only for the specifics of operating and maintaining the commissioned equipment, but also for providing the background information the EPA's O&M staff needs to be able to understand system operations and to apply practical preventive maintenance functions.

The CxA will have a significant positive impact on O&M training by doing the following:

- Recommend the necessary O&M staffing (total personnel, qualifications, and required shifts) to satisfy the owner's operational intent.
- Develop a facility preventive maintenance plan making best use of O&M staffing.
- Review the operation and maintenance manuals and verify that they are complete and available for training sessions. Prepare framed instructions showing the sequence of operations and interoperability of major systems and component.
- Ensure that the contractor uses adequate training materials and that the training is completed per the contract documents. The CxA should provide training agendas to the contractor's/manufacturer's trainers to review and use.
- Compile a systems manual consisting of the design record; space and use descriptions; single line drawings and schematics for major systems; control drawings; sequences of control; a table of all set points and the implications of changing them; time-of-day schedules; instructions for operation of each piece of equipment for emergencies, seasonal adjustment, startup, and shutdown; instructions for energy savings operations and descriptions of the energy savings strategies in the facility; recommendations for recommissioning frequency by equipment type; energy tracking recommendations; and recommended, standard trend logs with a brief description of what to look for in them. The systems manual with O&M manuals forms the master O&M manual.
- Prepare a recommended list of spare parts, bench stock, and special tools/equipment required for the first year of building operation.
- Deliver a final commissioning report summarizing the commissioning effort with a view of each piece of commissioned equipment relative to installation and start-up, functional performance, O&M documentation, and training. The commissioning record also contains the commissioning plan, functional tests, individual commissioning reports, reviews, and issues log.

attachments

Attachment 1 – Commissioning Process Matrix

Commissioning Process Matrix

Task	Description	Documents
Commissioning Agent Selection	Develop an RFP for commissioning services.	RFP Format Scope of Work Scoring Matrix
Commissioning Contract	Negotiate, prepare, and execute a commissioning contract.	Commissioning Contract
Design Team Kickoff Meeting	Initial kickoff meeting with the design team to establish the purpose and proposed process for commissioning the facility and to establish the individual roles and responsibilities.	Design Commissioning Plan
Owner Performance Requirements (OPR)	In cooperation with the EPA and the design team, the commissioning agent prepares a Design Intent summary document.	Owner Performance Requirements (OPR) Summary
Basis of Design	The design team prepares a Basis of Design document.	Draft Basis of Design
35% Plan Review	Complete thorough reviews of the 35% plan documents and submitted criteria (engineering calculations, system selection, and major component selection).	Review comments

Commissioning Process Matrix

Task	Description	Documents
65% Plan Review	Review 65% design documents (zoning requirements, specifications, typical room layouts, system main layouts, riser layouts, standard details, schedules, and coordination requirements). Draft preliminary construction commissioning plan, commissioning specifications, and supplemental commissioning language for other specification sections.	Review comments Draft Commissioning Plan Commissioning Specifications
95% Plan Review	Review 95% Design Documents. Update commissioning plan and final commissioning specifications.	Commissioning Specifications Draft Construction Commissioning Plan
Pre-bid Meeting and Assistance During Bidding Process	Pre-bid meeting to assist contractors in answering any questions about the systems or the commissioning process.	Written responses or recommendations
Construction Commissioning Kick Off Meeting	An initial commissioning meeting with all contractors and commissioning team members to establish the purpose and proposed process for commissioning the facility.	Final Commissioning Plan with specific individual responsibilities identified
Duration Schedule for Commissioning Activities	Duration schedule for the contractors for the commissioning activities required by the commissioning plan.	Duration Schedule
Submittal and Shop Drawing Review	Review all pertinent approved shop drawings to support the commissioning process. Submittals and shop drawings are reviewed for commissionability, maintainability, and compliance to the OPR. Note any issues that might compromise the final commissioned system on the commissioning review log and submit comments to the design team for resolution.	Commissioning Review Log

Commissioning Process Matrix

Task	Description	Documents
Construction Commissioning Plan	The commissioning plan will incorporate all changes established by review with EPA and the design team. The final commissioning plan will also include complete FIV, OPT, and FPT protocols for each system.	Final Construction Commissioning Plan FIV, OPT and FPT documents and protocols
Field Inspection Verifications (FIV)	Inspect the progress of construction with respect to the systems being commissioned; verify that the construction complies with the plans and specifications and standard construction quality practices.	FIV Check Sheets Daily Log Commissioning Issues Log
Commissioning Team Meetings	Hold commissioning meetings on a regular basis with the commissioning team to review progress of the commissioning effort and reinforce individual responsibilities.	Meeting Minutes Commissioning Issues Log
Complete all FIVs	Complete all field inspection verifications.	FIV Check Sheets Commissioning Issues Log
Operational Performance Tests (OPT)	Observe or facilitate all equipment and system start-up procedures. The contractor will execute all start up and point-to-point tests and the Cx will witness execution of all OPTs.	Completed OPTs Commissioning Issues Log
Functional Performance Tests (FPT)	Observe and facilitate all FPT testing. FPTs are designed by the commissioning authority and performed by the contractors.	FPT Check Sheets Commissioning Issues Log

Commissioning Process Matrix

Task	Description	Documents
Operator Training	Work with the contractor and owner to schedule and plan training activities so that training occurs in a coordinated and coherent fashion. Contractors and vendors provide all training.	Coordinated Training Agendas
Prepare Final Commissioning Report	Based on the accumulated commissioning work completed as described above, assemble the data into a final commissioning report.	Final Commissioning Report
Deferred (Off-season) Testing	Conduct any testing required by the commissioning plan that was deferred from the acceptance period.	Warranty Commissioning Plan FPT Test Check Sheets
Ten-Month Warranty Visit	Inspect the site and interview building operating personnel to identify any outstanding warranty failures and any persistent equipment failures that should be handled within the warranty period.	Commissioning Warranty Issues Log Commissioning Report Addenda

Attachment 2 – Commissioning Documentation

Commissioning Documentation Deliverables

Project Stage/Element	Documentation
Design Documents	The following documentation is typically generated during the design phase of a project and is included with or referenced in the commissioning package: User Requirements Specifications Conceptual Design Documentation Basis of Design Functional Requirements Specifications Personnel, Material, and Process Flow Diagrams Floor Plans and Architectural Drawings Detailed Design Specifications and Drawings Airflow, Zone, and Differential Pressure Diagrams P&IDs Equipment Specifications and Drawings Isometric Drawings Utilities and Power Requirements Sequence of Operations Documentation Panel and Wiring Diagrams Hardware/Software Specifications and Drawings Single Line and Electrical Drawings Schedules Equipment and Instrument Lists (including tagging identification) Design Meeting Minutes Design History Files Design Calculations
Procurement Documents	The following documentation is typically generated during the procurement of equipment, systems, and services: Contracts Bid Packages/Bid Tabs Purchase Orders Quotations/Proposals Bill of Materials Shipping Orders Receipt Verifications and Inspection Reports (of incoming deliveries) Detailed Design Documentation (from vendors/suppliers) Storage Instructions

Commissioning Documentation Deliverables

Project Stage/Element	Documentation
General Construction Documents	The following documentation is typically associated with and generated during the construction phase of a project: Submittals Shop Drawings Cut Sheets Daily Inspection Reports Construction Change-Order Documentation Access and Cleaning Logs Working/In-Progress “Red-Lined” As-Built Drawings RFIs and RFI Logs Punch-lists/Resolution Logs
Construction and Commissioning Documents – Equipment and Systems	The following documentation is typically generated during the procurement, construction, and commissioning of equipment and systems: Equipment Datasheets Component Catalog Cut Sheets Instrument Datasheets/Factory Calibration Records Detailed Parts List ASME Calculation and Certifications Materials of Construction Certifications, Mill Reports, and Coupons Surface Finish Certifications Welding Procedures, Welder Certifications, Samples, Coupons, and Records Weld Inspections Cleaning and Passivation Procedures and Records Recommended Spare Parts List Manufacturer’s Inspection Reports Spray Ball Pattern Tests/Riboflavin Tests Paint and Insulation Details As-Built Drawings Other Nondestructive Equipment Inspections

Commissioning Documentation Deliverables

Project Stage/Element	Documentation
Construction and Commissioning Documents – Piping Systems	The following documentation is typically generated during the construction and commissioning of piping systems: Piping Specifications Materials of Construction Certifications, Mill Reports and Coupons Surface Finish Certifications Isometric Drawings Pipe Slope Documentation Flushing and Cleaning Procedures and Reports Passivation Procedures and Reports Pressure Test Reports Welding Procedures, Welder Certifications, Samples, Coupons, and Records Weld Inspections/Boroscoping Valve Lists/Datasheets/Valve Tagging Pressure Relief Valves – Calculations and Certifications Rupture Disk Certifications As-Built Drawings
Construction and Commissioning Documents - HVAC/ Mechanical Systems	The following documentation is typically generated during the construction and commissioning of HVAC and mechanical systems: Ductwork and Accessories Specifications Shop Drawings Pressure/Leak Test Procedures and Reports Test, Adjust, and Balance (TAB) Reports Hydronic Balance Reports Filter Installation and Integrity Test Reports Filter/Airflow Certifications (smoke profiling, face velocity, etc.) Bio-Safety Cabinet and Fume Hood Certifications Dust Collection Airflow/Capture Velocity Test Reports As-Built Drawings

Commissioning Documentation Deliverables

Project Stage/Element	Documentation
Construction and Commissioning Documents – Instrumentation and Controls (including Process and Building Automation)	The following documentation is typically generated during the procurement, construction, and commissioning of instrumentation and controls, either as standalone systems or as part of equipment/systems: Instrument List and Calibration Records Hardware List and Datasheets Software Lists Control Panel Drawings Controls/Wiring Diagrams Input/Output List/Addressing Loop Check Documentation Screen Shots (printed screens) Program/Ladder Logic Printout Configurable Parameter/Set Point Lists Security/Password Profiles Sequence of Operations Documents Alarms and Interlocks Lists/Alarm Set Points/Test Results PID Configurations and Tuning Parameter Records Back-up Copy of Software with Configuration Database
Factory Acceptance Testing (FATs) & Site Acceptance Testing (SATs)	FATs/SATs: FAT/SAT Procedures/Protocols/Test Plans FAT/SAT Punchlists/Follow-up Reports FAT/SAT Final Reports Training Records During FAT/SAT Test Instrument Records

Commissioning Documentation Deliverables

Project Stage/Element	Documentation
General Commissioning Documents	The following documentation is typically generated as part of the overall commissioning effort: Commissioning Plans/Test Plans Pre-Functional Checklists Functional Checklists Impact and Criticality Assessment Reports Contractor Qualifications and Training Records Test Instrument Records Calibration Records/Logs Physical Completion Reports Supplier Start-up Procedures and Reports Supplier Operation and Performance Test Plans and Reports Punch Lists Discrepancy and Resolution Reports Engineering/Construction Change Order Records Commissioning Reports As-Built Drawings Training Records for Alpharma Staff Certificates of Conformity/Compliance Installation, Operation, and Maintenance Manuals (O&M) Safety Manuals Earthing, Bonding, and Continuity Checks Completion of Engineering Turnover Packages (ETOPs)

Attachment 3 – Commissioning Implementation Guideline

Rev. 10 3/25/08

Commissioning is required for all EPA new construction and renovation projects, unless they are architectural only (e.g. a new roof does not need to be commissioned) or if the Project Manager, SFPB Branch Chief, and AEAMB Branch Chief agree that commissioning is not justified.

1) For cases where EPA does not directly hire Commissioning Agent (GSA leases)

- Normally commissioning is provided by the Lessor, with EPA allowed to assist with final selection and oversight of Commissioning Agent. A common practice for a Solicitation for Offer (SFO) is to require three options for a Commissioning Agent from which to choose. The SFO should specifically request an outline of the commissioning plans, including scope and tests to be performed, from each proposed Commissioning Agent. FSMD should provide direct oversight of the commissioning on small projects and contract a Commissioning (Cx) Peer Review to fulfill EPA's oversight function for large projects.
- EPA oversight of commissioning includes:
  - Assist in commissioning agent selection
  - Review the commissioning plan
  - Review the commissioning team's experience and approach
  - Review commissioning team's reports at each stage of the actual process to ensure compliance with commissioning plan.
- EPA or Cx Peer Review provides feedback to commissioning agent through GSA.

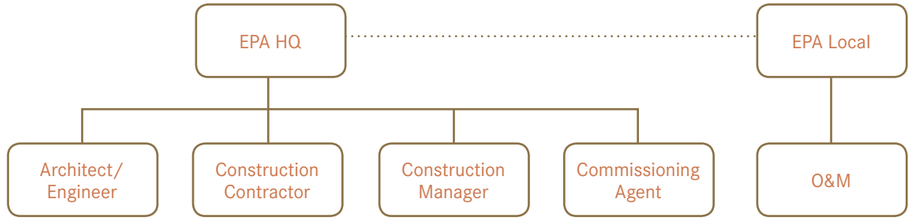
2) For cases where EPA directly hires Commissioning Agent (EPA owned facilities)

- Commissioning should be an independent third-party contracted by EPA-AEAMB Project Officer through Cincinnati CPOD. Commissioning is preferably achieved through a sub-contract with an unrelated design A/E but may be through a sub-contract with the same project design A/E as long as independent-third party status of the commissioning agent is maintained.
- Commissioning budget should be included in B&F budget. Commissioning agent selection shall be a collaborative process between AEAMB project officer and SFPB.
- SFPB will work with AEAMB to develop standard commissioning Program of Requirements (POR) for procurement of commissioning agents.
- AEAMB project officer will collaborate with SFPB to monitor and provide direction for the selected commissioning agent.

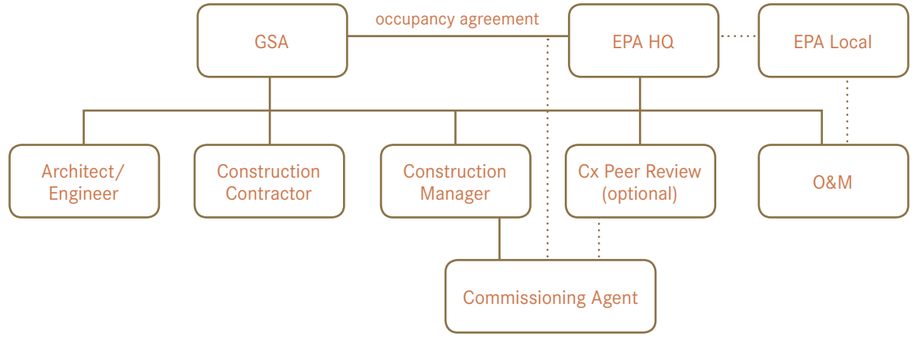
Illustration of procurement scenarios with respect to commissioning.

Solid lines indicate formal contract/agreement while dotted lines indicate oversight/input. Designer and construction manager may be combined in some cases and the construction contractor may be hired directly by either.

EPA-owned facility

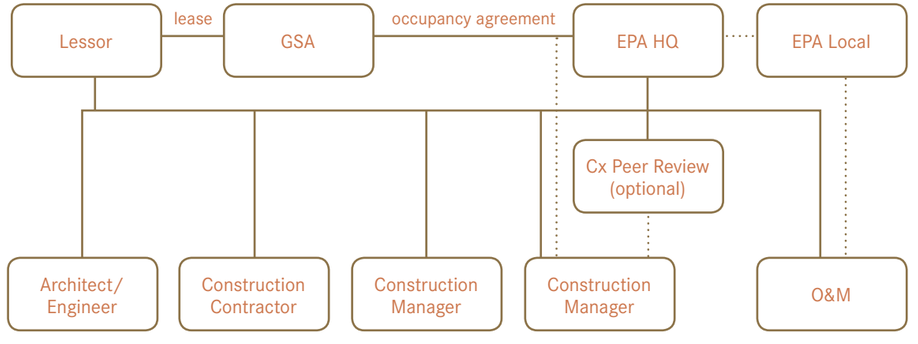


Full-service GSA occupancy agreement with GSA-owned building



Full-service GSA lease with lessor-owned building and GSA lease with lessor-owned building where EPA pays utilities

(GSA may provide oversight for both design and construction.)



Attachment 4 – Commissioning Roles and Responsibilities Matrix

Commissioning Roles and Responsibilities Matrix – Planning Phase

Planning Phase Tasks Documents/Data/Deliverables	EPA Project Manager	Architect/ Engineer (A/E)	Construction Manager (CM)	Commission-ing Authority (CxA)	Contractor
Identify Commissioning Team	●	●			
Develop Preliminary Commissioning Plan	●	●	●	●	
Develop Project Schedule (including Cx)	●	●	●	●	
Design Criteria, Project Details, or Conceptual Data	●	●			
System Requirements/Details/ Definitions/Plan	●	●			
User Requirement Spec/Document (URS/URD)	●	●			
Functional Requirements Specification (FRS)	●	●			
Calibration Program or Calibration SOP	●				
Preventive Maintenance (PM) Plan or PM SOP	●			●	
Establish Project Budget, including Cx scope	●	●	●	●	
Kick-off and Planning Meetings	●	●	●	●	

Commissioning Roles and Responsibilities Matrix – Design Phase

Design Phase Tasks	EPA Project Manager	Architect/ Engineer (A/E)	Construction Manager (CM)	Commission-ing Authority (CxA)	Contractor
Contract for Commissioning Agent Services	●				
Hold Design Stage Cx meetings	●	●		●	
Identify project specific responsibilities	●	●		●	
Review Owner's Project Requirements documentation for completeness & clarity		●		●	
Develop Basis of Design	●	●			
Perform focused Cx reviews of design drawings & specifications				●	
Perform project constructability reviews	●	●	●	●	
Incorporate appropriate changes to contract documents based upon design reviews	●				
Create Cx specifications including testing protocols for all commissioning equip./ systems				●	
Integrate Cx activities into project schedule	●	●	●	●	
Coordinate and integrate responsibilities between equipment, systems & disciplines	●	●		●	
Update Commissioning Plan	●	●			
Incorporate commissioning requirements into Construction Contractor's Scope of Work	●		●	●	

Commissioning Roles and Responsibilities Matrix – Bidding/Contract Negotiation Phase

Bid/Contract Phase Tasks	EPA Project Manager	Architect/ Engineer (A/E)	Construction Manager (CM)	Commissioning Authority (CxA)	Contractor
Bid Package and Associated Data	●	●	●		●
Purchase Order (P.O.)/Change Order (C.O.)	●	●	●		
Bill Of Materials (BOM) or Equipment or Valve Lists		●	●		●
Submittals or Equipment/System Data or Catalog Cuts		●	●		●
Startup/Test Procedures		●	●		●
Warranty/Service Contract Data	●	●	●		●

Commissioning Roles and Responsibilities Matrix – Construction Phase

Construction Phase Tasks Documents/Data/Deliverables	EPA Project Manager	Architect/ Engineer (A/E)	Construction Manager (CM)	Commissioning Authority (CxA)	Contractor
Finalize Commissioning Plan	●	●	●	●	
Review submittals applicable to equipment/systems being commissioned	●	●		●	
Review project submittals for construction quality control & specification conformance	●	●	●	●	
Develop Pre-functional Checklist (PFC)				●	
Review Pre-functional Checklist (PFC)	●	●			
Develop Functional Checklist (FC)				●	
Review Functional Checklist (FC)	●	●			

Commissioning Roles and Responsibilities Matrix – Construction Phase *continued*

Construction Phase Tasks Documents/Data/Deliverables	EPA Project Manager	Architect/ Engineer (A/E)	Construction Manager (CM)	Commissioning Authority (CxA)	Contractor
Install components & systems			●		●
Review RFIs & changes for impacts on Cx	●	●	●	●	
Execute and complete PFC's and FC's			●	●	●
Continuously maintain the record drawings and submit as detailed in the contract documents		●	●		
Coordinate functional testing for all commissioned systems & assemblies			●	●	
Perform quality control inspections	●		●	●	
Maintain record of functional testing			●	●	
Prepare Cx Progress Reports				●	
Construction phase Cx meetings	●	●	●	●	
Maintain Master Issues Log			●	●	
Compile and deliver final Commissioning Turnover Package				●	
Deliver final Construction Documents to the Commissioning Authority (CxA)		●			
Provide TAB Execution Plan			●		●
Review TAB Execution Plan	●	●		●	
Prepare Operation & Maintenance (O&M) Manuals			●	●	●
Review Operation & Maintenance (O&M) Manuals	●	●		●	

Commissioning Roles and Responsibilities Matrix – Warrantee Phase

Warrantee Phase Tasks Documents/Data/Deliverables	**EPA Project Manager**	**Architect/ Engineer (A/E)**	**Construction Manager (CM)**	**Commissioning Authority (CxA)**	**Contractor**
Approve Final Commissioning Turnover Package (Pre-Execution & Post-Execution)	●				
Approve Final Commissioning Report	●				
Prepare and turnover final As-Built Drawings		●	●		
Review equipment warranties to ensure responsibilities are clearly defined	●		●	●	
Implement training program for EPA Operating Personnel	●		●	●	●
Coordinate & supervise deficiency corrections	●		●	●	
Coordinate & supervise deferred & seasonal testing	●		●	●	
Review & address outstanding issues	●		●	●	
Review current building operation at 10 months into 12 month warranty period	●			●	
Perform Final Satisfaction Review with Customer Agency 12 months after occupancy	●			●	
Re-commissioning the facility at 3-5 years after turnover to reset optimal performance	●			●	
Identify and correct deficiencies found during commissioning			●	●	●

EPA Building Commissioning Guidelines

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Facilities Management & Services Division
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