Commissioning Services Guide

For project managers, construction teams and commissioning providers. Also for stakeholders in the commissioning process, including building owners and the balance of the project team.

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About the author

This guide was authored by Rick Dale, Director of Commissioning Services at Emanuelson-Podas. Dale is a Certified Commissioning Professional (CCP) through the Building Commissioning Association, holds a Commissioning Process Technical Service Provider accreditation (CxTS) from the University of Wisconsin and is a member of the Building Commissioning Association (BCxA). He currently serves on the exam committee for the Building Commissioning Certification Board (BCCB). He also holds a 4th Class Stationery Engineering License from the National Institute for the Uniform Licensing of Power Engineers. The process contained herein reflects practical experience and lessons learned from participating on project teams using industry best practices.

Introduction

About this Guide

The primary audience for this Commissioning Services Guide is comprised of project managers, their construction management teams and commissioning providers. The secondary audience includes the many stakeholders in the commissioning process, including building owners and the balance of the project team.

The Commissioning Services Guide provides: the overall framework and process for building commissioning from project planning through tenant occupancy, keys to success within each step and the ways that each team member supports the process of commissioning. This guide will be used in conjunction with the Project Specifications. It details the commissioning activities, and the tasks within each phase of the Project Planning and Execution Process. While recognizing that every project is unique and that the required activities will vary, this quide provides recommendations, minimum requirements and best practices based upon industry guidance. The guide encourages the use of these best practices to ensure completeness and consistency and to address the facility needs of the building owners.

The Commissioning Services Guide is organized into the following sections:

- Philosophy Provides the Emanuelson-Podas (EP) philosophy, definition and expectations for commissioning, as well as an overview of the benefits of commissioning.
- The Commissioning Process Details the considerations, practices and recommendations for commissioning, including the Pre-Design, Design, Construction and Occupancy and Operation Phases, as well as LEED specific requirements.
- Appendices Provides samples and tools.

Background

Development of this Commissioning Services Guide included a thorough review of leading industry commissioning publications and processes. This guide incorporates industry guidance and best practices suggested by such leading organizations as:

- American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Guideline 0-2013
- American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Standard 202-2013
- Building Commissioning Association (BCxA), The Building Commissioning Handbook
- Portland Energy Conservation, Inc. (PECI)
- U.S. Department of Energy
- U.S. Green Building Council (USGBC) LEED
- California Commissioning Collaborative, California Commissioning Guide, New Buildings, 2006

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) offers a definition of commissioning and provides instructions on how the Commissioning Process should be performed. Per ASHRAE'S Guideline 0-2013, this process is defined as, "A quality-focused process for enhancing the delivery of a project. The process focuses on 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."

By following the Commissioning Process as part of Commissioning Best Practices, potential Owners Project Requirements (OPR) issues such as performance problems, occupant comfort complaints, indoor air quality issues and reduced equipment life can be identified early and resolved with minimal impact. The output of the Commissioning Process is enhanced delivery, reduced cost of construction projects and buildings that function according to the OPR.

Commissioning is not a single occurrence but rather a process that ensures a building meets the best quality and reliability performance for its budget. It is not an additional layer of project management or construction. The Commissioning Process typically involves four distinct phases, during which specific tasks are performed by the various commissioning team members. The four phases are:

- Design

The process begins during the Pre-Design phase and continues through the Occupancy and Operations phase and ultimately through the life of the facility. Although commissioning can begin during start-up in the Construction phase, the process offers significantly greater and more cost-effective benefits when it begins during Pre-Design. It is the driving force during construction and the essential process for final turnover and acceptance of the facility.

Commissioning Philosophy

The Commissioning Process

 Pre-Design Construction Occupancy and Operations

A properly applied Commissioning Process ensures quality for each aspect of the facility. Within the Commissioning Process, the Commissioning Provider (CxP) is responsible for quality assurance. The installing contractor is responsible for quality control. For the owner, the Commissioning Process helps clearly define and document the requirements for the facility. For the designer, the Commissioning Process helps promote understanding of the Basis of Design (BOD) and the selection of the best tools and equipment for the facility. For the contractor, the Commissioning Process helps with proper installation and start-up of equipment and components. Finally, the Commissioning Process provides training and a finished building guideline that can be used by maintenance personnel to properly maintain the new facility. See appendix A to review the Commissioning Process Flow Diagram.



Goals of the Commissioning Process

The overall goal of commissioning is to construct a facility that operates as intended and meets the Owner's Project Requirements. In addition to this goal there are several specific sub goals that will be achieved as a direct results of the commissioning process:

- Provide a safe and healthy facility for employees
- Improve energy performance
- Reduce operating cost
- Improve orientation and training of staff
- Improve documentation of the facility
- Provide guidance for re-commissioning of the facility

Benefits of the Commissioning Process

The primary benefit of the commissioning process is to serve as the overall guality program for the project. Because all building systems are integrated, a deficiency in one or more components can result in suboptimal operation and performance among other components. Incorporating the Commissioning Process early in a project can result in a variety of benefits including:

- Greater collaboration among all professionals involved in the project
- Improved on-time, on-budget delivery of projects Better building documentation

throughout the building life cycle

Reduced maintenance cost

Enhanced environmental/health conditions and occupant comfort

satisfaction

Increased occupant and owner

- Improved system and equipment function
- Improved building operation and maintenance conditions and system life cycle

Glossary of Terms

Acceptance - A formal action, taken by a person with appropriate authority (which may or may not be contractually defined) to declare that some aspect of the project meets defined requirements, thus permitting subsequent activities to proceed.

Approval - Acceptance that a piece of equipment or system has been properly installed and is functioning in the tested modes according to the contract documents.

Basis of Design (BOD) - A document that records the concepts, calculations, decisions and product selections used to meet the owner's project requirements and to satisfy applicable regulatory requirements, standards and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.

Checklists - Checklists that are

developed and used during all phases of the Commissioning Process to verify that the owner's project requirements are being achieved. This includes checklists for general verification, plus testing, training and other specific requirements.

Commissioning Authority (CxA) or Commissioning Provider (CxP) -The entity identified by the owner who leads, plans, schedules, and coordinates the commissioning team to implement the Commissioning Process.

Construction Checklist - A form used by the contractor to verify that appropriate components are onsite, ready for installation, correctly installed and functional. Construction Documents - This

includes a wide range of documents which vary from project to project based on the owner's needs, local regulations and applicable state and county laws. Construction documents usually include the project manual (specifications), plans (drawings) and general terms and conditions of the contract.

Commissioning Plan - An overall plan developed by the Commissioning Provider (CxP) that provides the structure, schedule and coordination planning for the Commissioning Process.

Commissioning Process (Cx) - A

quality-focused process for enhancing the delivery of a project. The process focuses upon 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.

Commissioning Process Progress Report - A written document that details activities completed as part of the Commissioning Process and significant findings from those activities that is continuously updated during the course of a project. Usually it is incorporated into the Commissioning Plan as an ongoing appendix.

Commissioning Team - All individuals who through coordinated actions are responsible for implementing the Commissioning Process.

Contract Documents - This includes a wide range of documents which vary from project to project based on the owner's needs, local regulations and applicable state and county laws. Contract documents frequently include price agreements, the construction management process, sub-contractor agreements or requirements, procedures for submittals and other construction requirements, timeline for completion, and the construction documents.

Data logging - The monitoring and recording of flows, currents, status, pressures, etc., of equipment using stand-alone data recorders separate from the control system or the trending capabilities of control systems.

Deficiency - A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the contract documents.

Factory Testing - Testing of equipment on-site or at the factory, by factory personnel, with or without an owner's representative present.

Functional Performance Testing -The process of putting the Direct Digital Control (DDC) system through its paces by manipulating various condition the controls and equipment will experience.

Issues Log - A formal and ongoing record of problems or concerns - and their resolution - that have been raised by members of the commissioning team during the course of the Commissioning Process.

Owner's Project Requirements

A written document that details the functional requirements of a project and the expectations of how it will be used and operated. This includes project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information. (The term "Project Intent" is used by some owners for their Commissioning Process owner's project requirements or design.)

Pre-Functional Testing -

See Construction Checklists above.

Project Definition Rating Index -

Refine the assessment of the project definition for completeness and verify that major risk issues have been identified and mitigation plans are in place or developed. And to provide part of the decision criteria for proceeding to the next phase.

Quality Based Sampling - A process for evaluating a sub-set (sample) of the total population. The sample is based upon a known or estimated probability distribution of expected values; an assumed statistical distribution based upon data from a similar product, assembly, or system; or a random sampling that has scientific statistical basis.

Re-Commissioning - An application of the Commissioning Process requirements to a project that has been delivered using the Commissioning Process. This may be a scheduled re- commissioning developed as part of an ongoing Commissioning Process, or it may be triggered by use change, operations problems, or other needs.

Retro-Commissioning -The

Commissioning Process applied to an existing facility that was not previously commissioned. This quideline does not specifically address retro-commissioning. However, the same basic process needs to be followed from pre-design through occupancy and operations to optimize the benefits of implementing the Commissioning Process philosophy and practice.

Start-up - The initial starting or activating of equipment, including completion of manufacturer-required activities by authorized personnel.

Systems Manual - A system-focused composite document that includes the operation manual, maintenance manual and additional information of use to the owner during the occupancy and operations phase.

Test Procedure - A written protocol that defines methods, personnel and expectations for tests conducted on components, equipment, assemblies, systems and interfaces among systems. The test procedures are specified in the Technical Specifications sections of the contract documents. Performance testing covers the dynamic functions and operations of equipment and systems using manual or monitoring methods. Performance testing is the dynamic testing of systems under full operation. Systems are tested under various modes, such as during low cooling loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system's sequences of operation and components are verified to respond as the sequences state.

Training Plan - A written document that details the expectations, schedule, budget, and deliverables of Commissioning Process activities related to training of project operating and maintenance personnel, users, and occupants.

Verification - The process by which specific documents, components, equipment, assemblies, systems and interfaces among systems are confirmed to comply with the criteria described in the Owner's Project Requirements.

Trending – The monitoring, by a building management system or other electronic data gathering equipment, and analyzing of the data gathered over a period of time.

Overview

The Commissioning Process should be interwoven with the overall Project Planning and Execution Process. This guide only outlines the necessary steps within the Commissioning Process, without detailing all of the Project Planning and Execution Process steps.

Certification on LEED Project

Define/Revie Owner's Proje Requirements th the Owner Rep and PM

The Commissioning Process

Retain mmissior Provider

Develop Initia Commissionin Plan

Verify Owner's oject Requireme & Basis of Desig

Concept, sign Developm Construction

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commissioning schedule and egrate into mas project schedule

PM (Project Manager) Lead • CxP (Commissioning Provider) Final Phase Step Lead

Review submitta RFIs & change rders for impact

Feam Meetin and Report Progress

Develop/review Cx test documents, onstruction checklist rendor start-up test action and integrat performance test

quality site nspection of contractor tallations wc

equipment/system tartup operation a start-up test rep

Functional and Performance Testing

Record to Swner's Re

Direct and ver seasonal and deferred testin

Review system erformance bef end of warrant period

Complete fi Commissi

arned workshop and lude lessons learned m application of the Commissioning Process



During the Pre-Design stage, the Project Manager must establish commissioning as an indelible piece of the overall delivery process.



Commissioning

Agent Services

Commissioning

Develop Initial Commissioning Plan

Commissioning Certification Requirements (on LEED Projects)

Owner's Project Requirements with the Owner's Rep and PM

Initial Budget

or Commissioning

Retain Commissioning Provider Services

The first step in the Commissioning Process is for the PM to identify and hire the Commissioning Provider (CxP). The CxP must have significant in-building commissioning experience, including technical and management expertise on projects of similar scope, size and type. The CxP and the PM generally have different skills. In general, the PM provides management, technical and administrative expertise during the pre-design, design and construction phases to ensure that the Owner's goals relating to schedule, budget, scope and guality are met. A CxP has technical background and in-depth expertise with the Commissioning Process, including verification techniques, functional, integrated performance testing, system equipment and O&M knowledge.

Identify Commissioning Team

The Commissioning Team is responsible for working as a cohesive unit to assure that all the steps in the Commissioning Process are completed and the facility objectives are met. The initial commissioning team lays the groundwork and plan for commissioning at later phases. The Commissioning Roles and Responsibilities Matrix* is a summary interpretation of the individual roles of team members. Even though it is likely that key team members (i.e. CM, A/E, OP) will not be on board at this stage of the project, completion of a project specific roles and responsibility matrix will help the CxP identify tasks and resources needed during the design, construction, and occupancy and operations phases of the project.

Pre-Design Phase

During this stage, the Project Manager (PM) must establish commissioning as an indelible piece of the overall delivery process. Adequate consideration for commissioning scope, budget and schedule shall be included in planning the project. Further, it is at this stage that the Owner's Project Requirements are developed. These requirements form the foundation for the design, construction, and occupancy and operation of the facility and are the basis for the commissioning plan and schedule.

The next step in the Commissioning Process is for the PM to work with the CxP to identify the makeup of the Commissioning Team. The members of the commissioning team will vary depending on the project type, size and complexity. In general the team will consist of:

- Project Manager (PM)
- Operating Personnel (OP)
- Owner Representative(s)
- Technical Experts (Structural,
- Mechanical, Electrical,
- Fire Protection)

- Construction Manager (CM)
- Construction Contractor and Subcontractors Commissioning Provider (CxP)
- Architect/Engineer (A/E)
- Commissioning Technicians

Pre-Design Phase

Develop Initial Commissioning Plan

The Commissioning Plan* defines the Commissioning Process and the myriad commissioning activities required for the quality assurance process to achieve the OPR. The Commissioning Plan identifies the commissioning responsibilities of each member of the commissioning team.

This Commissioning Plan includes as a minimum:

- Introduction
- General Project Information
- Commissioning Process
- Commissioning Scope
- LEED criteria
- Commissioning Schedule
- Team Contact Information
- Communication Plan and Protocols
- Commissioning Documentation

The Commissioning Plan may be the most dynamic document in the project because it undergoes the greatest amount of change during all phases of a project.

Commissioning for Certifications - LEED Requirements

Development of the preliminary Commissioning Plan and scope shall include a review regarding project certifications and goal attainment. For the project to be LEED certified, Commissioning Process activities must comply with the prerequisite requirements for fundamental building commissioning. The project team may also opt to pursue an added LEED point for Enhanced Commissioning. Refer to the appropriate LEED Guide for your given project type (new construction, existing building, etc.) to review all commissioning requirements.





Commissioning Certification Requirements (on LEED Projects)

Define/Review Owner's Project Requirements with the Owner's Rep and PM

Establish Initial Budget or Commissioning

Buoyancy Laboratory; Mission Control Center; etc. with some labs, building automation, more **Complex:** Moderate plus most of the floor area in more systems (fire, emergency, power, etc.). complex systems (e.g. hospitals, labs, operating Simple: Office buildings, classrooms, rooms, clean rooms, fume hoods or other non-HVAC systems) are commissioned such as packaged equipment and controls; common electrical quality, transformers, security, systems, fewer pieces of equipment. communications, etc. Traveling requirements and Portland Energy Conservation, Inc. (PECI) 2000 high cost of living locations increase costs.

Pre-Design Phase

Define/Review Preliminary Owner's Project Requirements

One of the main objectives of commissioning is to provide documented confirmation that a facility fulfills the functional and performance requirements. To attain this goal, it is necessary to review the Owner's Project Requirements (OPR) and have the owner agree to the initial document and to subsequent changes.

The CxP's role in this phase is to facilitate development of the OPR. The OPR forms the foundation for the design, construction and occupancy and operation of the facility, and is the basis for the Commissioning Plan and schedule moving forward. The OPR will evolve throughout each project phase. As decisions are made throughout the Pre-design, Design and Construction Phases, the OPR will be updated.

Establish Initial Budget for Commissioning

The CxP develops the initial commissioning budget. This budget is based on the level of commissioning services desired by the owner and the systems, the assemblies chosen to be commissioned and the complexity of the systems chosen. The budget is documented as part of the Commissioning Plan and includes all Construction Commissioning activities.

Commissioning Costs

Factors that influence commissioning cost include the level of commissioning desired, the complexity of the systems and assemblies chosen to be commissioned, the facility type (office building, lab building, manufacturing facility, school) and the depth of commissioning services (trending, temperature profiling, building energy modeling). It is critical that the overall established budget which is submitted for funding approval contains necessary allocation for commissioning.

Benchmark Commissioning Costs by Facility Type



Estimates of Construction Phase Commissioning Costs:

Specialty: Very complex facilities - Neutral

Moderate: More complex office, classroom control strategies, fewer packaged equipment;



The CxP may recommend changes to improve energy efficiency, operation and maintenance, and equipment reliability resulting in cost savings to the project.

Verify Owner's Project Requirements & Basis of Design

Concept, Design Development, Construction Documents, Design Review

> Establish Commissioning Planning Meetings

Develop Commissioning Specifications

schedule and ntegrate into master

> Commissioning Plan

documents.

The Basis of Design (BOD) is developed by the A/E early in the Design Phase based on the OPR. The BOD clearly depicts the assumptions made in developing design solutions that meet the criteria in the OPR document. It is the primary document that translates owner's needs into building components such as HVAC systems, building envelope, security systems, building automation system, etc. The BOD is used to expand the Commissioning Plan to include the details of Construction, Occupancy and Operations Phase commissioning activities.

One of the CxP's first tasks is to review the Owner's Project Requirements and the Basis of Design (BOD). The purpose of these reviews is to assure the owner's needs are met as described in the Owner's Project Requirements, and carried through in the Basis of Design Documents. The CxP's review ensures clarity and completeness with an eye toward Commissioning Process activities. The CxP may recommend changes to improve energy efficiency, operation and maintenance and equipment reliability resulting in cost savings to the project.

The Commissioning Provider provides three focused reviews of the design documents. It is recommended that these reviews occur first at the end of Schematic Design (30%), the second shall occur during Design Development (60%) and the third toward the end of Construction Documents Phase (90%). The CxP compares the design against the needs as identified in the OPR. The CxP identifies any improvements that can be made in areas such as energy efficiency, indoor environmental quality, operations and maintenance, etc. Though the CxP is responsible for reviewing the design from a commissioning perspective, the CxP is not responsible for design concepts and criteria.

This phase is marked by the commissioning kickoff meeting during which the CxP outlines the roles and responsibilities of the project team members and also reviews the Commissioning Plan outline and schedule. Team members provide comment on the plan and schedule and the CxP uses these suggestions to update the Commissioning Plan. All outstanding comments and issues relative to the CxP's review of the design shall be resolved, and accepted changes shall be incorporated into the contract and construction bid documents

Design Phase

The Design Phase is the Commissioning Team's opportunity to ensure that the efficiency and operational concepts developed during the Pre-Design Phase are included in the final design and that they will function according to user expectations. Specific tests and procedures designed to verify the performance of systems and assemblies are developed and incorporated into the contract

Verify Owner's Project Requirements and Basis of Design

SD, DD and CD Reviews

Commissioning Planning Meeting

Design Phase

Develop Commissioning Specifications

The commissioning tasks for the contractors will be identified in the Commissioning Specifications* and will include:

- General commissioning requirements common to all systems and assemblies
- Detailed description of the responsibilities of all parties
- Details of the Commissioning Process (i.e., schedule with durations and sequence of activities)
- Reporting and documentation requirements and formats
- Alerts to coordination issues
- Deficiency resolution

- Commissioning meetingsSubmittal Reviews
- O&M Manuals
- Pre-Functional Construction checklists
- Functional testing process and specific performance test requirements, including testing conditions and acceptance criteria
- As-built drawings
- Training
- Specifications must clearly indicate who is witnessing and documenting start-up of each commissioned system. Specifications must also clearly indicate who is writing, directing, conducting and documenting functional tests. The CxP and the PM must work together to ensure that commissioning requirements are fully integrated and coordinated in the project specifications.

Develop Commissioning Schedule

As a guide, the commissioning specifications must include a copy of the pre-design Commissioning Plan. The Commissioning Plan contains the best projection of how the commissioning activities will be integrated into the master project schedule. Based on information obtained in the pre-commissioning plan, the BOD, design reviews and commissioning specification, the CxP develops the commissioning schedule. This schedule includes all testing to be completed by the commissioning team and includes durations, dates and resources needed to complete the testing. The CxP works with the PM to ensure the commissioning schedule is an integral part of the master project schedule.

Update Commissioning Plan

At this point, the pre-design phase Commissioning Plan is updated to reflect all the commissioning team's reviews, comments, approved updates and commissioning test philosophy. The Design Phase Commissioning Plan is now the governing document that defines the Commissioning Process moving into the construction phase. Verify Owner's Project Requirements & Basis of Design

Concept, Design Development, Construction Documents, Design Review

> Establish Commissioning Planning Meetings

Develop Commissioning Specifications

Develop commissioning schedule and integrate into master project schedule

Update Commissioning Plan

Contract Documents Aligned with Owner's Project Requirements

* Appendix D: Sample Commissioning Specification



During the Construction Phase of the Commissioning Process, systems and equipment are installed, inspected, tested and placed into service to meet the OPR.

Construction Phase

During the Construction Phase the CxP coordinates and directs the commissioning activities in a logical, sequential and efficient manner. The two overarching goals of the Construction Phase are to assure the level of guality desired and to assure the requirements of the contracts are met. During the Construction Phase of the Commissioning Process, systems and equipment are installed, inspected, tested and placed into service to meet the OPR. The Construction Phase commissioning activities are a well-orchestrated quality process that includes installation, start-up, functional and integrated performance testing and training to ensure documented system performance in accordance with the OPR.

Review Submittals, RFIs and Change Orders

The CxP's review of submittals, RFIs and change orders shall be restricted to those items that are critical to the focus of the Commissioning Process. The CxP shall pay particular attention to proposed deviations and substitutions from contract documents and the BOD. The CxP will only comment on submittals, RFIs and change orders to the extent that there is an apparent deviation from the OPR or Commissioning Plan.

Hold Commissioning Team Meetings

The commissioning team meetings take place during this phase, during which the CxP updates the progress of the commissioning activities. At this point in the project the commissioning meeting should be held weekly. Any issues or performance concerns are recorded on the issues log for resolution. Each meeting agenda should include commissioned system status, planned testing, and issue log review and resolution. Also the CxP should attend selected job-site meetings to obtain information on construction progress.

Develop and Review Commissioning Tests

The CxP reviews contractor submittals of commissioned equipment, OEM manuals, and the control specification then writes detailed test plans for each system and piece of equipment to be commissioned. The sequence of operations and controls specifications must provide sufficient detail to ensure that functional testing documents can be written in such detail as to thoroughly test the functionality of each system. These test plans are reviewed with the contractors and project team for detailed understanding of test activities. \Detailed testing plans include: Construction Checklists, Construction Start-up Tests, Vendor Startup Tests, Functional Tests, Installation Verification Tests and Performance Tests.

Perform Quality Site Inspection

The CxP performs site visits to observe component and system installation from a quality perspective. The CxP witnesses some but not all construction installation tests (piping pressure test, ductwork pressure test, piping cleaning, etc.) and includes the documentation in the commissioning records. The CxP reviews the completed construction checklists for good documentation practices and completeness prior to proceeding to equipment start-up activities.

Review submittals, RFIs & change orders for impact on commissioning

Commissioning **Report Progress**

Cx test documents. construction checklists, vendor start-up test, function and integrated performance test

> site inspection nstallations work

verify completion of start-up test report

Direct & Functional and

Conduct Owne Commissioning Owner's Rep

Review submittals RFIs & change orders for impact on

Report Progress

Cx test documents, construction checklists, vendor start-up test, function and integrated performance test

> site inspection of contractor nstallations work

Witness initial equipment/system startup operation and verify completion of start-up test report

> Direct & Document Functional and Performance Testing

Conduct Owner

Record to

Performance

17 Commissioning Services Guide Team Meetings and Develop/review

Perform quality

Witness initial

Construction Phase

Witness Initial Equipment/System Start-Up

This is the point in the project at which equipment first gets energized. This is the only time in the Commissioning Process where 100% of the Start-up commissioning activities are witnessed by the CxP. The construction start-up and vendor start-up test reports have already been reviewed and approved by the CxP. The CxP witnesses the initial start-up of all equipment by the contractor and/ or vendor and reviews the start-up test reports for completion and approves the results. These documents should be included in the commissioning reports.

Direct and Document Functional and Integrated Performance Testing

At the heart of the Commissioning Process is the execution of the functional and integrated performance testing. Functional testing involves equipment testing and/or loop testing of individual controls and systems. Integrated performance testing includes all system integrations and interdependences between systems.

Written functional and integrated performance test procedures define the means and methods to carry out system/intersystem tests during the construction phase. The CxP coordinates and/or writes the detailed test plans for each system and piece of equipment to be commissioned. The test shall be written to include operating the system and components through each mode of operation including: start-up, shutdown, manual mode, power failure and alarming.

The CxP coordinates all functional and performance testing but the actual execution and documentation of testing is performed by the installing contractors, controls contractor and/or the commissioning technicians. Testing deficiencies and/or equipment malfunctions are noted in the Issue Log (deficiency punchlist) for resolution by the contractor. The CxP tracks all deficiencies for resolution and completeness and coordinates all retesting activities once the testing deficiencies and/or equipment malfunctions have been corrected. If design corrective measures are required, the CxP ensures that they meet the owner's criteria and the design intent, at times involving the design team and owner for resolution of responsibility or strategy.

Construction Phase

Conduct Owner Training

An important step in the Commissioning Process is ensuring that Operating Personnel are properly trained in the maintenance and operations of the new facility, equipment and systems. To facilitate this training, the building operations staff should have participated in construction checklists and functional testing activities. This involvement improves operator understanding of the proper operation of equipment and systems. It also provides operators with valuable hands-on training in running and troubleshooting the equipment they will manage.

This process begins in the Design Stage by assuring that appropriate levels of training are planned and included in the commissioning specifications. The CxP also reviews agendas and material developed by the contractors in advance of the trainings for quality, completeness and accuracy. The CxP shall also attend key training sessions to evaluate effectiveness and suggest improvements in the delivery of the material.

Turnover Commissioning Record

The Construction Phase is complete when the facility has moved from the static construction state to the dynamic operating state free of major deficiencies. This transitional phase is called "Substantial Completion." Control of the building is transferred from the design/construction team to the building owner/operators prior to the completion of this phase.

It is important to understand that commissioning documentation developed throughout all the phases of the project is collected and assembled as part of a turnover package for a given system. Documentation related to system manuals, training, and operation and maintenance are also collected and assembled as part of the deliverables for that system. Commissioning documentation turned over at this stage of the project is the result of a detailed, comprehensive Commissioning Plan.

Review submittals RFIs & change orders for impact on commissioning

Commissioning Report Progress

Cx test documents, construction checklists, vendor start-up test, function and integrated

Perform quality

Witness initial startup operation and verify completion of start-up test report

Direct & Conduct Owne Training Commissioning Record to **Owner's Rep**

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Occupancy and Operations Phase

In most cases, Commissioning Process activities continue until the end of the warranty period. The Occupancy and Operations Phase of the Commissioning Process begins at substantial completion. During this phase, the ongoing operation, maintenance and any re-testing (resulting from deficiencies listed in the issues log) are verified against the OPR. The Commissioning Process includes the formal acceptance by the CxP and owner of building operations. Occupancy and Operations Commissioning Phase team activities may include:

- Coordination of contractor call-back
- Verification of deferred and seasonal testing of systems and equipment
- Documentation of lessons learned from application of the Commissioning Process for the next project
- Acceptance of Occupancy and Operation Commissioning Phase activities
- Completion of the final Commissioning Report for the project

Coordinate Deficiency Resolutions from Issues Log

The issues log is maintained by the CxP and becomes part of the final Commissioning Report. During this phase the CxP coordinates and supervises all re-testing resulting from deficiencies listed in the issue log. This issue log is also a guide used to track all deferred and seasonal testing.

Direct and Verify Seasonal and Deferred Testing

Due to seasonal conditions, not all systems modes can be tested at full load during the Construction Phase. Commissioning Plans shall include deferred season testing to allow for testing of certain equipment under full load conditions. In addition to seasonal testing, several systems may have been deferred during the initial testing due to deficiencies (including prerequisite activities not being completed), phased occupancy issues and improper testing environment.

Review System Performance Before End of Warranty Period

During the first year of the building's operation it is important to assure that the performance of the facility is maintained, particularly before the warranty period expires. Ten months into the warranty, the CxP should perform a review of the systems and equipment with the operating personnel and PM to identify any potential warranty issues and decide which must be repaired or replaced under warranty. This review is based on warranty items and continued performance against the Owner's Project Requirements. Discrepancies between design and actual performance may indicate a need for retesting and/or minor system modifications.



deficiency esolutions from deferred testing

performance before

Complete final Commissioning Report

Conduct lessons learned workshop and include lessons learned from application of the Commissioning Process

resolution

Conduct Lessons-Learned Workshop

One of the major benefits of the Commissioning Process is greater collaboration among all professionals involved in the project. As a final close-out to the project the PM should conduct a lessons-learned workshop. The findings should be used to improve the Commissioning Process for future projects

Occupancy and Operations Phase

Complete Final Commissioning Report

During the Occupancy and Operations phase, the CxP is responsible for delivering a final Commissioning Report. This final report should include: • The activities of the commissioning process

- The important issues resolved and unresolved and any recommendations for
- A statement that systems have been tested and completed in accordance with the contract documents and that the systems are performing in accordance with the final Owner's Project Requirements document
- Identification and discussion of any substitutions, compromises or variances between the final design intent, contract documents and as-built conditions





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		The Commissioning Process	Retain Commissioning Provider services	Identify Commissioning Team	Develop Initial Commissioning Plan, Include LEED Criteria as required	Review LEED Commissioning Certification Requirements (on LEED Projects	Define/Review Owner's Project Requirements with the Owner's Rep and PM	Establish Initial Budget for Commissioning	Commissioning integrated with Front End Planning (FEP) Documents		Verify Owner's Project Requirements & Basis of Design	Conduction Cx Concept, DD and CD Design Reviews	Commissioning Planning Meeting	Develop Commissioning Specifications	Develop commissioning schedule and integrate into master project schedule	Update Commissioning Plan	Contract Documents Aligned with Owner's Project Requirements
Legend:	L = Lead S = Support A = Approve R = Review I = Input P = Participate	Project Planning and Execution	Pre-Design Prelim Design Activity	Prelim Design Activity	Prelim Design Activity	Prelim Design Activity	Prelim Design Activity	Prelim Design Activity	Prelim Design Activity	Design	Detailed Design Activity	Detailed Design Activity	Detailed Design Activity	Detailed Design Activity	Detailed Design Activity	Detailed Design Activity	Detailed Design Activity

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Project Planning and Execution	The Commissioning Process	Owner or Owner's Rep Project Manager - PM	CxP Engineer Engineer	CxP Technician	Architect	Structural Design Engineer	Mech. Design Engineer	Electrical Design Engineer	Fire Protection	Control Engineer	Construction Manager	Deneral Contractor	Partice Participation Participation						
Construction																			
Const. Startup & Cx Activity	Review submittals, RFIs & change orders for impact on commissioning	R		۹.	_	_	_	_	_	_	S/P							ш. 	
Const. Startup & Cx Activity	Hold Commissioning Team Meetings and Report Progress	R		٩	S	S	S	S	S	S	S/P	0	<u>д</u>	<u> </u>	<u> </u>		0	<u>ц</u>	-
Const. Startup & Cx Activity	Develop/review Cx test documents, construction checklists, vendor start-up test, function and integrated	R		۵.	S						R	0	<u></u> д		ш.	ш		Ľ.	~
Const. Startup & Cx Activity	Perform quality site inspection of contractor installations work	R			S						P/S	0	<u>е</u>	<u>د</u>	<u> </u>		0	ш.	-
Const. Startup & Cx Activity	Witness initial equipment/system start-up operation and verify completion of start-up test report	R		L/F	S						P/S	0			ш	ш ,	<u> </u>	ш 	
Const. Startup & Cx Activity	Direct & Document Functional and Performance Testing.	R	S		S						S	0	<u>д</u>	<u> </u>	<u> </u>				-
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Occupancy & Operations																			
Project Turnover Activity	Coordinate deficiency resolutions from issues log	R	_	L/F	0												4	Ľ	~
Project Turnover Activity	Direct and verify seasonal and deferred testing	R		₽													4	-	01
Project Turnover Activity	Review equipment performance before end of warranty period	R		٩													+		~
Project Turnover Activity	Complete final Commissioning Report	R	_	S													4	Ľ	~
Project Turnover Activity	Conduct lessons learned workshop and include lessons learned from application of the	P/I L	P	<u>م</u>													4	Ľ	-
Project Turnover Activity	System Performance Documented & Accepted	R	<u>م</u>	S													~		~

25 Commissioning Services Guide

Appendix B



Available Upon Request

Appendix D – Commissioning Requirements Specifications

Available Upon Request





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