White Paper:

BUILDING COMMISSIONING

The Early Project Phases

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Those who have a familiarity with the commissioning process may well recognize the process of executing checklists at the jobsite. These commissioning tasks are, after all, the most visible, inclusive and definitive elements of the commissioning process. The checklists (or Test Protocols) are, however, the result of considerable upfront effort and planning that starts during the project development phase.

COMMISSIONING PROCESS OVERVIEW

Commissioning is a quality process, not unlike those used in manufacturing, but is geared toward buildings. Commissioning, as defined in the new construction building industry, is "a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria"[1].

Commissioning, as all quality processes, is a continuum that persists throughout the lifecycle of high performance buildings. Commissioning process steps are generally accepted as being:

- Planning Phase
- Design Phase
- Construction Phase
- Acceptance Phase
- Persistence Phase

A "V" Model approach to the building commissioning process can be depicted as

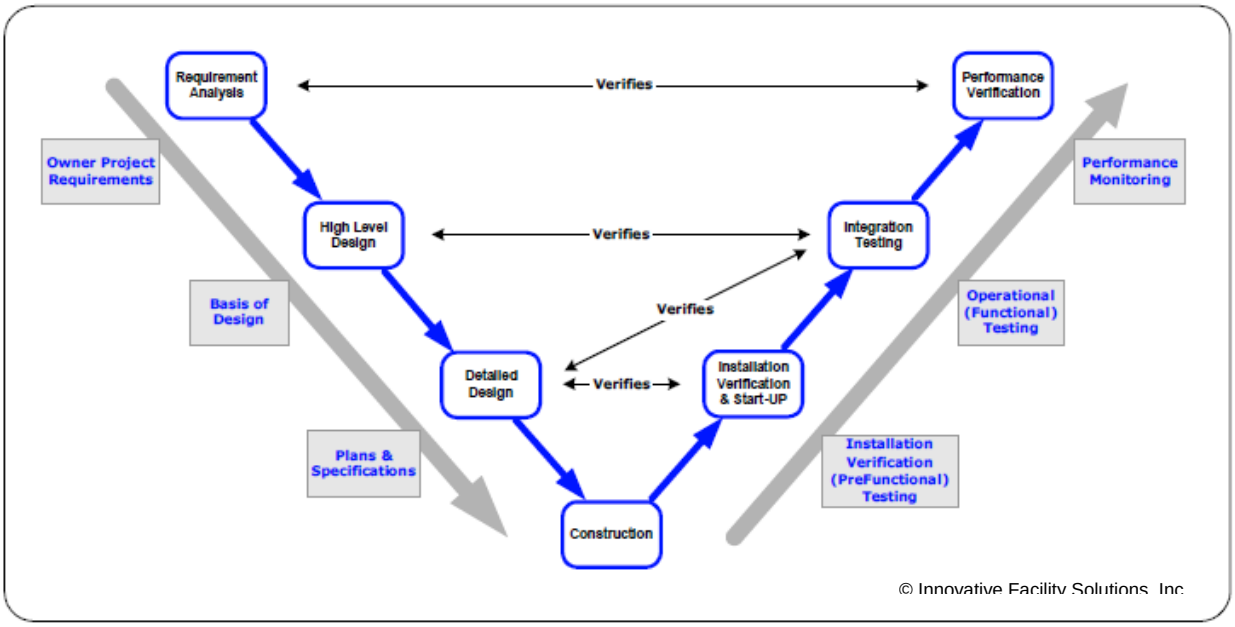

Figure 1 – Commissioning "V" Model

The Commissioning Process guides and documents the achievement of the "…defined objectives and criteria." per the ASHRAE definition of Commissioning. The "V" Model depicts this as "Requirements Analysis" which are typically manifested as the Owners Project Requirement document. This paper will focus on the "Planning Phase" and "Design Phase" commissioning activities. These activities align with the "Programming" and "Design" phases of a new building

[1] ASHRAE Guideline 0, The Commissioning Process

project and encompass the commissioning activities associated with the three elements on the left side of the "V" Model.

PLANNING PHASE COMMISSIONING

Planning Phase Commissioning aligns with the project's programming phase. There are several outputs from Planning Phase Commissioning

- Establishment of a quality process (i.e. Commissioning) as an integral project component
- Develop the Scope of Commissioning
- Selection of a Commissioning Authority
- Commissioning Team Development
- Develop the Owner Project Requirements

From the building construction standpoint, Commissioning is an "End Game" strategy. It provides documented evidence that the building and its systems perform as intended and gives the owner a means to sign off on final payment. The commissioning documentation also provides construction professionals a method to establish completion in a systematic, methodical manner.

The effectiveness of employing Commissioning as an "End Game" strategy increases in proportion to when and how this quality process is adopted as a project strategy. As shown in Figure 2, the opportunities to leverage the benefits of the Commissioning Quality Process diminish as a function of the project progress.

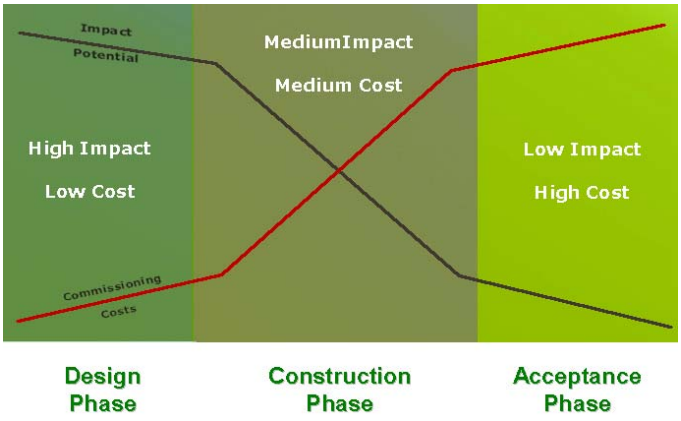

Figure 2 – Commissioning Effectiveness

Establishing Commissioning as an integral component of new building construction at the project inception yields the maximum value to the project. Since commissioning is only now becoming mainstream component in the new building construction process, this truism is often only understood once an owner has completed a project that incorporated commissioning as an integral project component.

In the conceptual phase of the project, the commissioning scope can be defined in broad terms. The building type and intended use can be a guide with a general assessment of risk associated with the intended building systems. Studies have shown that HVAC and Building Control systems have a high potential for installation deficiencies.[2] Including these systems in the Commissioning Scope is good practice. LEED and other certification systems may dictate additional systems, such as Lighting, Lighting Control, Renewable Energy Systems and Domestic Water Heaters as requiring commissioning.

At this juncture a determination of whether or not to include items such as the building envelope, emergency power systems, domestic water systems, water reclamation systems, security systems, transport systems, specialty systems, etc. can be assessed. In addition to the conventional risk assessment items such as Health and Safety, Productivity, Liability, etc., an

[2] Mills, E et al., "The Cost-Effectiveness of Commissioning New and Existing Commercial Buildings: Lessons from 224 Buildings" National Conference on Building Commissioning: May 4-6, 2005 <http://eetd.lbl.gov/emills/PUBS/PDF/NCBC_Mills_6Apr05.pdf >

owner and operator of a building might also consider the risks associated with deficiencies in accurate as-built documentation, ineffective owner/occupant training, lack of documented system performance testing, and lack of comprehensive systems manuals. LEED and other certification systems may also recognize these efforts (i.e. LEED v3 [2009] grants a credit for Building Envelope Commissioning).

Scope development also encompasses the level, or degree, of commissioning activities and tasks. A matrix, similar to that shown in Figure 3 is a useful tool to align the rigor of the commissioning activities with the risk assessment.

Commissioning Scope Assessment

Risk Assessment Section
H=High
M=Medium
L=Low

Commissioning Scope Section (Complete for H & M Risk Items)
X=Include in Cx Scope

Building System/Component	Risk Assessment: Health & Safety Risk	Risk Assessment: Productivity Risk	Risk Assessment: Liability Risk	Risk Assessment: Operating Cost Risk	Commissioning Scope Assessment: Accurate as-built documentation	Commissioning Scope Assessment: Operations Training	Commissioning Scope Assessment: Documented Performance Testing	Commissioning Scope Assessment: Comprehensive Systems Manual	Commissioning Scope Assessment: Include in Commissioning Scope	Comments / Remarks
Building Envelope										
Roof	M	L	H	H			x		x	
Glazing	M	L	M	H			x		x	
Exterior Walls	L	L	L	H			x		x	
HVAC	M	H	M	H	x	x	x	x	x	
Emergency Smoke Exhaust	H	M	H	L	x	x	x			Documented Testing Req'd for CO
Building Automation	L	M	L	H	x	x	x	x	x	
Emergency Power Generation	H	L	M	L	x	x	x		x	
Renewable Power Generation	L	L	L	H	x	x	x	x	x	
Lighting and Lighting Control	M	H	L	M	x	x	x	x	x	
Verticle Transport	H	M	L	L						Documented Testing Req'd for CO

Figure 3 – Commissioning Scope Assessment

Selection of a commissioning authority can follow naturally to development of a thoughtful commissioning scope. Potential candidates as the commissioning authority include

- An Independent Third-Party Commissioning Firm
- An A/E Firm
- A General Contractor
- The Project Construction Manager
- The Owner's Personnel

There are pro's and con's to each of the potential candidate types and that discussion will not be presented in this paper. LEED and other certification systems, however, prefer independent Third-Party Firms for their inherent objectivity. Seeking out the most appropriate provider for the project workscope also considers the experience, credentials, references, and ability of the provider to meet the project schedule. Since there are no universally recognized standards for commissioning best practices it is prudent to evaluate the potential provider's methodology, commissioning approach, and sample documentation to understand how the provider will integrate with the project stakeholders. It can be challenging to determine the cost of commissioning services at this early stage of the project, but the following rules of thumb, generally hold true.

An effective commissioning team includes every project stakeholders that has, or will have, responsibilities or usage of the systems that are included in the commissioning scope. Chief among these are the owner project and maintenance representatives, the building occupants, the design professionals and the construction professionals. Vendors of complex and/or specialty equipment are also encouraged to be active team participants in proportion to the impact that their equipment may have on the building operation. Assigning a dedicated representative, with decision-making authority, for each entity in the commissioning project team will provide continuity throughout the project development, construction, acceptance, and occupancy.

Commissioning Costs[3]

Actual Commissioning Costs, as Reported in a Study of 69 Commissioning Projects

Description	Value or Ranges
Total Cx Cost	$0.49 – $1.66 / SqFt
Cx Provider Fee as % of Total Commissioning Cost	74-86%
Provider Fee as & of Total Construction Cost	0.3 – 1.1%
Design Review	18%
Construction Observation	14%
Acceptance Testing	64%
Warranty	4%

Figure 4 – Commissioning Costs

The Owners Project Requirements is a document that details the owner's functional requirements for a project and expectations for how it will be used and operated. These include project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.

The commissioning agent or design team may assist the owner in developing or reviewing the Owners Project Requirements documentation for the building. The owners objectives may be developed through a meeting of owner stakeholders with the design team and commissioning agent in attendance. At a minimum, the commissioning agent reviews the Owners Project Requirements for clarity and completeness.

The Owner Project Requirements is often a living document that is modified and updated as the design development progresses and budget/schedule analysis are conducted. The commissioning authority assists to assure that updates to the Owner Project Requirements are documented and communicated to all project stakeholders.

DESIGN PHASE COMMISSIONING

Planning Phase Commissioning aligns is conducted during the project's design development phase. The elements of Design Phase Commissioning are:

- Review the Basis of Design document
- Conduct Design Reviews
- Prepare and/or Review Commissioning Specifications
- Develop the Commissioning Plan

The Basis of Design (BOD) is developed by the A/E early in the Design Stage based on Owner's Project Requirements. It is the primary document that translates Owner's and the user's needs into building components such as HVAC systems, building envelope, security systems, building automation system, etc. The BOD describes the technical approach planned for the project as well as the design parameters to be used and the assumptions made for sizing and selection of systems (i.e. codes, standards, operating conditions, design conditions, weather data, interior environmental criteria, other pertinent design assumptions, etc.). The BOD is typically developed

by the A/E and done in technical terms, whereas the Owner's Project Requirements are developed by Owner and User and expressed in layman's terms.

Commissioning design reviews provide the opportunity for an independent set of eyes to appraise the design against the Owner's Project Requirements and the Basis of Design. Three focused reviews at design inflection points are sufficient for commissioning purposes as follows:

- At the end of Design Concepts,
- During Design Development (50%)
- Toward the end of Construction Documents Phase (95%)

The Commissioning Authority compares the design with the interests and needs of Owner as identified in the Owner's Project Requirements. Any improvements that can be made in areas such as energy efficiency, indoor environmental quality, operations & maintenance, etc. are noted. Though the Commissioning Authority is responsible for reviewing the design from a commissioning perspective, the Commissioning Authority is not responsible for design concepts, design criteria or compliance with local, State and Federal Codes. The Commissioning Authority does not approve the design, but makes recommendations to facilitate commissioning and improve building performance.

Figure 5 – Sample Cx Plan Table of Contents

Before the 95% Construction Document review, the Commissioning Authority facilitates the development of commissioning specifications into the design. Commissioning specifications define the contractors' commissioning-related responsibilities, including equipment installation and start-up, documentation, and testing. Including specifications in the contract documents ensure that the contractors are aware of their responsibilities and are afforded the opportunity to include the costs of commissioning related activities in their delivery schedule and project pricing. Conversely, the owner also is afforded the opportunity to tie payment schedules and other contract language to the to the commissioning activities.

The Commissioning Plan is a comprehensive document that defines the project's commissioning activities, schedule, documentation requirements, deliverables, and the roles and responsibilities of team members. This document is drafted during the design development and finalized at the onset of the project construction phase. Figure 5 depicts Sample Toble of Contents of a Commissioning Plan may include:

It is advantageous to solicit consensus of the Commissioning Plan through signature of the major project stakeholders such as the Owner Representative, Design Professionals and Construction Professionals.

Conclusions

As high performance and sustainable building practices become mainstream, building commissioning is becoming recognized as an essential element of new building construction. Commissioning benefits all of the project stakeholders and its costs are easily recovered through enhanced building performance, occupant productivity, and reduced liability.

The importance of the commissioning activities that take place during a projects conception and design development are not as generally understood as the more recognized construction phase commissioning activities such as completing commissioning checklists. It is, however, these early stage commissioning activities that ultimately expedite the project closeout, helps to minimize change orders, and lowers the impacts of contractor call-backs, warranty, and other items associated with the projects shake-down period.

Involving a Commissioning Authority during the programming phases of a project's development maximizes the benefits that commissioning affords at the highest possible value.