Total Building Commissioning

Building commissioning provides owners and designers increased assurance that buildings will perform as expected

— by James T. Morrissey, Michael Amstadt, and Rita Seraderian, PE, FPCI, LEED AP

Building commissioning is quickly becoming a key component in green codes and standards, and a requirement of owners who are concerned that their high-performance buildings perform as designed. High-performance design principles have gained traction in the design community and among owners for their ability to enhance the service life of facilities and reduce life-cycle costs. There is an increased recognition of the importance of ensuring that building systems, glazing, and superstructure are delivering on the designer's assumptions.

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The U.S. Environmental Protection Agency (EPA) defines the importance of building commissioning to them: "In many ways, commissioning is similar to a 'test run' or 'systems check.' It tests, verifies, and fine-tunes the performance of key building systems so that the highest levels of performance are achieved. Correctly implemented, commissioning is extremely cost-effective, and should improve the building delivery process, increase systems reliability, improve energy performance, ensure good indoor environmental quality, and improve operation and maintenance of the facility."[1]

One critical aspect of the commissioning process is the need to begin it during schematic design. Early involvement of the commissioning agent aids the design professional in developing the Owner's Project Requirements (OPR), the subsequent design team Basis of Design (BOD) and the beginning of the Operations & Maintenance (O&M) Systems Manual. These tools are vital elements in the commissioning process, and if their development is delayed until the construction documents (CD) phase, the commissioning process may have to be modified to fit the design, resulting in the loss of performance improvement critiques during CD development, and a reduced ability to effectively track system quality after construction.

The basic goals of building commissioning are best defined in the Whole Building Design Guide (WBDG), a website developed by the National Institute of Building Sciences:

According to WBDG, the goals of commissioning are to:[2]

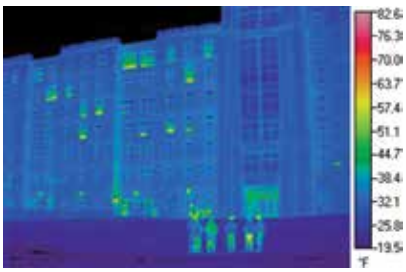
1. Define and document requirements clearly at the outset of each phase and update through the process;
2. Verify and document compliance at each completion level;
3. Establish and document commissioning process tasks for subsequent phase delivery team members;
4. Deliver buildings and construction projects that meet the owner's needs, at the time of completion;
5. Verify that operation and maintenance personnel and occupants are properly trained; and
6. Maintain facility performance across its life cycle.

The Commissioning Authority (CxA) can be contracted by anyone of the stakeholders, such as the owner, facilities manager, design team, construction manager, or even the contractor. The commissioning services can include new construction or renovations. Even existing facilities can be scoped for fundamental, enhanced, or total building commissioning. Guidelines for the commissioning process can be specified by American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), National Environmental Balancing Bureau (NEBB), the Building Commissioning Association (BCA), or a selection of many other organizations.

Commissioning and LEED

As for LEED®, fundamental commissioning is a base requirement, and therefore does not add any points to the total required for certification. The minimum requirements of systems

Catholic University's Opus Hall utilized precast concrete sandwich wall panels to create their thermally efficient envelope.



Thermal imaging shows that the precast concrete walls have no thermal bridging. All Photos: Little.

to be commissioned only include energy-consuming components of the mechanical systems HVAC, lighting controls, and domestic hot water systems. Enhanced commissioning provides three points toward LEED certification and consists of fundamental commissioning with the design phase and warranty phase tacked on to the commissioning scope. The design phase commissioning work includes two design reviews, at 60% and 95% completion of construction documents, and either preparing or reviewing the design professional's commissioning specifications. Reviewing the OPR and BOD is also required. The warranty phase includes facilities personnel training, review of systems manuals, an 11-month inspection after occupancy, and possibly seasonal testing.

There is much more to commissioning. It is important to make sure everything that operates within a building, and protects it from damage, protects its occupants from harm, is designed and installed properly, and works as intended. Some additional systems or components which should be considered for commissioning include: power distribution, emergency power, life safety, communications, domestic water supply, fire suppression, conveying systems, and the building envelope. With manufacturing, healthcare, and laboratory facilities, additional systems and equipment might also include clean steam, medical gasses, laboratory gasses, purified water, fume hoods, isolation rooms, incinerators, and process equipment. This is called Total Building Commissioning (TBC).

Envelope Commissioning

A number of factors are leading owners, designers, and construction professionals to adopt building envelope commissioning. These factors include: the growing complexity of building envelope design, increasing numbers of different construction materials, shrinking schedules, increasingly stringent performance demands, and the need to construct energy-efficient buildings. Building envelope commissioning is a means to ensure that the building envelope is constructed to meet the design intent, expected service life, and code requirements, as well as to aid in the prevention of complications that otherwise might arise during the construction process. It involves a number of different components, such as opaque walls, roof, windows, curtain walls, foundation, caulking, acoustics, air, vapor, moisture, and thermal barriers. There needs to be communication starting at the design development phase, to establish the owner's performance requirement for each component. During the design phase, the commissioning agent reviews the design and specifications to confirm that all pieces are included and all trade scopes are clearly and fully defined. During the construction phase, submittals are reviewed for conformity with the design documents and installations are inspected periodically to confirm adherence with the design and approved submittals, as well as standard construction practices.

The testing phase involves prescribed test procedures to verify the envelope's ability to meet the design requirements related to water penetration, thermal resistance, humidity, and air barrier requirements. These tests typically include timed roof

flooding, water pressure applications, building pressurization, and infrared thermography—all of which should be written into the specifications and witnessed by the commissioning agent. In some cases, commissioning may continue beyond project completion. Envelope commissioning will then be able to facilitate and ensure that the required communication, coordination, testing, verification, and documentation results in the delivery of a building envelope that performs as specified, as designed, and within budget.

As for testing, the most effective tool used in the commissioning process is the infrared camera. With a building pressurized and a sufficient temperature differential, infrared thermography (IRT) can detect opening in the buildings enclosure and thermal bridges. Wet sub-materials, such as roof insulation or masonry back-up, can also be detected with IRT, indicating leaks in the superstructure.

Air barrier testing is now required for all new federal buildings with an allowable air leakage of 0.25 CFM per SF of building surface at 75 pa (30" wc). Once the building construction is completed, the testing team is scheduled for a nighttime operation. The general contractor seals all designed openings (door jambs, dryer vents, etc.) with tape. The building is pressurized with mobile fans incrementally up to the 75 pa limit. Differential pressure readings are a taken across a door opening. With the data collected and the building surface area provided, the air leakage rate can be calculated. This is normally done with a software package. During pressurization, IRT is performed on the outside of the building, including the roof. The process is then reversed for depressurization with the data recorded in similar manner. The IRT is performed on the inside of the building as well.

In many cases, however, commissioning is not considered until a project reaches the construction phase. While still valuable, implementing commissioning after construction begins will be less effective than comprehensive commissioning, which starts at the predesign phase, because there is less opportunity to organize and plan ahead.

The objectives of the building envelope-commissioning process are driven by building type, expected life cycles, geographic location, climatic considerations, desired energy efficiency, budgetary constraints, and tolerance for leakage, all of which may vary considerably among projects. While the commissioning goals and benefits are common, the precise tasks comprising the commissioning process will differ from project to project.

One of the best performing envelope systems in this test are precast concrete panels, due to their low permeability, continuous insulation, and thermal mass. Like any exterior wall system, however, the design professional must take care to carefully detail flashing and sealant joints, and utilize the commissioning agent to confirm that they are installed properly. The advantage of precast concrete sandwich walls over other systems, such as glass curtain walls or metal panels, is that precast envelopes require far fewer joints than these other systems. While IRT testing does not address the integrity of the vapor barrier or thermal barrier, the integrity of these systems can be measured with temperature and humidity mapping while the building HVAC is providing climate control.

Building envelope commissioning is a rapidly growing AEC project management practice because of its benefits. Commissioning of the building envelope helps to ensure that all of the building systems are working properly and efficiently, protected from undesirable outside elements, and that indoor environment is maintained as intended.

1. U.S. Environmental Protection Agency (EPA), "Commissioning." Last modified July 07, 2012. Accessed July 11, 2013. http://www.epa.gov/iaq/schooldesign/commissioning.html.
2. National Institute of Building Sciences, "Building Commissioning." Last modified June 11, 2012. Accessed July 11, 2013. http://www.wbdg.org/project/buildingcomm.php.

To learn more about building commissioning, design professionals and owners may want to access these resources:

1. General Services Administration (GSA) Building Commissioning Guide: http://www.wbdg.org/ccb/GSAMAN/buildingcommissioningguide.pdf http://www.gsa.gov/portal/category/21064
2. The Whole Building Design Guide (WBDG) Building Commissioning section: http://www.wbdg.org/project/buildingcomm.php

For more information on these or other projects, visit www.pci.org/ascent.

Commissioning Standards

The Commissioning Industry is being driven by several organizations, each with their own guidelines and standards. Several of the key players in this process are ASHRAE's Guideline 0-2005, NEBB's Procedural Standards for Whole Building Systems Commissioning, BCA's New Construction Building Commissioning Best Practices, LEED® and the National Institute of Building Sciences (NIBS) Guideline 3-2012, Building Enclosure Commissioning Process. Most commissioning documents either reference ASHRAE Guideline 0-2005 or roughly align with it. This also aligns with the LEED® certification program since LEED® v2009 for both Fundamental Cx (EAp1) and Enhanced Cx (EAc3) reference ASHRAE Guideline 0-2005. Also to standardize the commissioning process, ASHRAE is in the final stages in the development of Standard 202 – Commissioning Process for Building and Systems, which defines the minimum efforts to meet the needs of commissioning. With Standard 202 providing minimum requirements, Guideline 0-2005 is the best practice document for defining building commissioning.