

COMMISSIONING ***THE TOTAL PROCESS***

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ABSTRACT

In recent years, most new buildings have been equipped with increasingly sophisticated heating, ventilating, and air-conditioning (HVAC) systems, energy conservation equipment, lighting systems, security systems, and environmental control devices that rely on electronic control. Very frequently these systems and design features have not performed as expected. This can result in energy-efficiency losses, occupant complaints about comfort, indoor air quality problems, high operating costs, and increased liability for building owners, operators, employers, and design professionals.

Building commissioning was developed in response to these concerns. Commissioning involves the examining and testing of building systems to verify aspects of the building design, ensure that the building is constructed in accordance with the contract documents, and verify that the building and its systems function according to the design intent documents. The process helps to integrate and organize the design, construction, operations, and maintenance of a building's systems to produce a healthy, comfortable, and efficient facility.

INTRODUCTION:

Commissioning and performance testing is commonly performed when building systems are constructed and preferably, once again 12 months after occupants have been using the building and all systems have been operating. However, a good commissioning process actually begins during the design phase with development of the design intent documents and agreement on how the design intent criteria will be verified and documented during the post-construction and post-occupancy assessments. Construction observation, functional performance testing, operator training, and record documentation complete the initial process. Recommissioning on an annual basis is also advantageous as a means of ensuring the proper functioning and upkeep of building systems throughout their useful lives. Given its importance and many potential benefits, commissioning is becoming part of good standard practice for the industry.

The commissioning industry has developed guidelines for the implementation of the commissioning process. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) has published *Guideline 1-1996, The HVAC Commissioning Process*. This guideline defines commissioning as "The process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent". A recent article on commissioning points out that a synonym for commissioning might be discovery. Commissioning leads to discovering what doesn't work, under controlled conditions, at a time when failures will not impact occupant activities, so as to make corrections which will produce a facility operating as intended.

BENEFITS OF BUILDING COMMISSIONING:

- Commissioning is a process more than an event. It facilitates the communication of the owner's design intent for the facility to the design, construction and building operations teams
- The building-commissioning process provides for testing and verification of building systems to ensure that they perform as designed and meet expectations for comfort, air quality, energy consumption and maintainability.
- The commissioning activities and documentation ensure that systems are installed as designed, thereby reducing the occurrence of problems at the project's completion and over the life of the building.
- The building-commissioning process is used to discover deficiencies in the building and its systems before occupancy. It is more cost-effective to correct any deficiencies (both in design and construction) at that time.
- Construction-phase and post-occupancy building commissioning improve the building systems' performance under real, live conditions, reducing the potential for user complaints.

- The building-commissioning process helps ensure the proper functioning of buildings with good indoor air quality.
- Using the HVAC system design documentation as a checklist ensures that the HVAC system capacity meets the projected peak and actual thermal loads for population and equipment. This review reduces the need for potentially costly construction change orders, which in turn reduces construction costs and the architect's potential liability.
- The building-commissioning process provides the design team with a better understanding of the building's systems, resulting in improved design and better coordination of the construction documents.
- Recommissioning a building throughout its life on a regular, annual, or biannual, schedule ensures the proper functioning of systems on a continuing basis. By maintaining indoor air quality, building recommissioning may also reduce worker complaints and improve worker productivity. This in turn may reduce the building owner's potential liability.

THE COMMISSIONING TEAM:

A good building-commissioning process requires leadership, planning, thorough documentation, and systematic implementation. The process requires a team approach along with strong central control. The implementation of the "Partnering" process, or team building with common objectives, is often beneficial in accomplishing good commissioning results.

The commissioning team should consist of appropriate representatives of the owner, designer, constructor, and building operators. Each has specific responsibilities governed by their function and the facility requirements. A brief list of some of these is as follows:

The Commissioning Team

a. *Owner:*

1. Assign project management responsibility.
2. Select independent commissioning authority.
3. Develop and approve design intent documents.
4. Assign maintenance personnel to be included in the process.
5. Review and approve any changes to design intent, and final design documents including commissioning

plans.

6. Monitor construction, testing, and commissioning process.
7. Assure the participation of all appropriate personnel in training programs.
8. Operate and maintain the facility in accordance with approved plans and programs.

b. *Commissioning Authority:*

1. Assist with the preparation of design intent documents.
2. Prepare the initial commissioning plan outlines and assist designer in preparation of final commissioning plan.
3. Review design documents to assure compliance with design intent.
4. Review construction and installation to assure compliance with design intent, and materials and procedures resulting in acceptable performance.
5. Execute and coordinate the performance testing and commissioning process.
6. Coordinate and supervise the training of operations staff.
7. Consolidate and finalize the commissioning report and project as built documentation, and systems manuals.

c. *Architect:*

1. Support the commissioning process.
2. Design the facility to meet the design intent, comply with the required air quality and design standards.
3. Include required commissioning specifications and documentation in the construction documents.
4. Select materials to minimize contaminants during construction and occupancy.
5. Include the commissioning authority in all appropriate stages of the process.

d. *Engineer:*

1. Support the commissioning process.
2. Design all systems to meet the design intent and comply with required design standards, ventilation requirements, and material selections.
3. Include the commissioning authority in all appropriate stages of the process.
4. Prepare the final commissioning plan, develop testing and verification criteria and report formats, and include these in the construction documentation.
5. Define the organization and format for the systems manuals and commissioning reports.
6. Participate in all appropriate training.

e. *Contractors:*

1. Support the commissioning process, include the cost of commissioning in estimates.
2. Utilize construction methods and materials to minimize building contaminants and protect the construction workers and occupants.
3. Provide all required documentation including; submittals, as-builts, operation and maintenance manuals, start-up and testing reports, and documents and descriptions required for the commissioning report.
4. Assist, support and participate in verification and commissioning activities
5. Provide and participate in appropriate training.

THE THREE PHASES OF COMMISSIONING

Commissioning is divided into three phases. The first is the program and design phase that produces the construction documents. Next, the construction and acceptance phase which includes the facility construction, testing records, functional verification, training and documentation. Finally, the post-acceptance phase monitors the building operations, retests on a periodic basis, and can last through building demolition.

Design and Construction Documents Phase

- Develop and document the owners program and overall vision for the facility. Select the building Systems to be covered in the commissioning process. In large and sophisticated buildings, many systems are integrated. Expanding commissioning activities to cover multiple systems is often beneficial. The following is a list of additional Systems that should be considered for commissioning:

EXAMPLES OF SYSTEMS THAT REQUIRE COMMISSIONING

1. Mechanical
 - Hot Water Heating Systems
 - Pumps
 - Boilers and Humidifiers
 - Cooling Towers
 - Refrigeration Machines
 - Air Handling Equipment
 - Fans – Supply and Exhaust
 - VAV Systems
 - Terminal Boxes
 - Air Handling Services
 - Fire/Smoke Dampers

Computer Room A/C Units

2. Electrical
 - Emergency Generator Systems
 - Lighting Control Systems
 - Fire Alarm Systems
 - Security Systems
3. Controls
 - Building Management Systems
 - Direct Digital Controls
 - Air Handling Equipment
 - Terminal Boxes
 - Air Flow Measuring Stations
 - Fire Management Systems
4. Fire Management Systems
 - Smoke Exhaust Systems
 - Fire and Smoke Dampers
 - Fire Pump Systems
 - Fire sprinkler Systems
 - Fire Alarm Systems
 - Stairwell Pressure Systems
5. Other Systems
 - Elevators
 - Laboratory Systems
 - Kitchen Equipment

- Develop a strategy to implementing the building-commissioning process. Ensure that the commissioning strategy encompasses all of the necessary activities in each stage of the process.
- Prepare the design intent documentation and design criteria for the HVAC system, including the following information:
 - The HVAC system building commissioning design documentation form.
 - The HVAC system design criteria, and the HVAC system description.
 - The building comfort and ventilation criteria.
 - The building utility requirements and systems.
 - Lighting, noise and energy conservation criteria.
 - Control systems and interconnections.
- Use these HVAC system design documents to:
 - Verify with the building owner or users the occupants' anticipated building program requirements and their planned activities and equipment,
 - Verify the fire and life safety code requirements for the number of occupants,
 - Verify with the mechanical engineer the ventilation requirements for the occupants and their equipment

so the HVAC system is designed with sufficient capacity to provide outside air for the projected building population and the anticipated heat-producing equipment.

- Have the design team and building operators review the documents to confirm that the building is properly designed for its intended uses. The building population and equipment should not be increased beyond the design limits for the HVAC system.

- Prepare design documentation and design criteria for the other building systems to be commissioned according to the format used for the HVAC system process.

- The commissioning process should be described in the Division 1 sections of Construction Specification Institute (CSI) documents. The Division 1 sections should also refer the user to the appropriate technical sections for additional information about each system's commissioning details.

- Specify facility startup amount in the commissioning section of Division 1 specification. The facility startup amount is the total dollar amount that the project sponsor allocates to commissioning in the project specifications and is released to the contractor at the successful completion of each phase of the commissioning. This facility startup amount needs to be determined prior to construction commencement and should be allocated to the general contractor for coordination and to specific subcontractors for their commissioning work.

- Ensure that the commissioning process is addressed in contract documents and construction meetings. Contract documents should accurately reflect the process agreed upon for building commissioning. The architect should also be asked to describe the commissioning process at any pre-bid or pre-construction conferences and at pre-commissioning meetings.

- Form a commissioning team and designate a commissioning authority. The ASHRAE guidelines define the commissioning authority as the qualified person, company, or agency that will plan and carry out the overall commissioning process. There are many options as to who should be selected to serve this role, including the design professional, the building owner, or a commissioning consultant/agent. It is often useful to form a commissioning team that

works together to commission the building. In this situation, the role of commissioning authority is divided among various members of the commissioning team, with specific members taking the lead in each phase of the project. Another approach is to consider hiring an independent commissioning agent to ensure that the commissioning is performed adequately.

Construction Phase

- Involve the design team in monitoring the construction commissioning process. During the construction phase, the contractor plays the major role in performing the building commissioning. However, the design team should also be involved in monitoring the building commissioning process. Since this is a relatively new process, "partnering" or team building may be required to ensure success. The benefit of partnering is that it establishes a forum for alternative dispute resolution so that building equipment and system problems can be resolved quickly in "real time."

- Conduct pre-commissioning workshops and commissioning progress meetings. Workshops and progress meetings are useful in ensuring that all building commissioning issues are properly addressed. Attendees should include members of the commissioning team.

- Observe that construction is in accordance with the contract documents. The architect should monitor commissioning process, meetings, and workshops to ensure that this construction process is generally performed in accordance with contract documents. Ultimate responsibility for full-time observation rests with the owner's field representatives.

- Perform systems and equipment startup. In this phase, the contractor should start the operation of building systems and equipment so they may be tested, inspected, adjusted, balanced, and corrected if necessary.

- Demonstrate operations and conduct training. Training seminars and on-site "hands-on" training should be conducted for the building operators. The contractor should provide the systems and equipment operations and maintenance manuals.

- Commissioning Authority recommends acceptance

of the work and payment of the facility startup amount. The architect and consulting engineers should review the work prior to acceptance.

- Prepare the commissioning report. On facilities where total commissioning is performed and when that commissioning process is complete, the commissioning agent should issue a commissioning report to the owner, including the following information:

- Building description, including size, location, and use;
- Team members and responsibilities;
- The final project design documents and the commissioning plan and specification;
- A written and/or schematic description of each project system including architectural, mechanical, and electrical systems included in the project;
- A summary of system performances relative to the design intent;
- Completed pre-functional checklists;
- Completed functional checklists and air quality base line data;
- All approval, non-compliance, and cost-tracking forms; and
- The manuals for each system, which should include the following information:
 - a. System design intent;
 - b. System description;
 - c. As-built drawing, specifications and approved submittals;
 - d. Emergency shutdown and operational procedures;
 - e. Test-and-balance and other testing reports;
 - f. Startup and verification checklists and reports;
 - g. Operations and maintenance manuals;
 - h. Material safety data sheets (MSDSs), and chemical disposal requirements; and
 - i. Training documents and programs.

Post Occupancy Phase

- Conduct fine-tuning of building systems and equipment after one year. This phase of the commissioning activity should occur after the building is occupied and operating under normal and planned conditions for approximately 12 months. Fine-tuning is an extremely important part of the commissioning activity and provides the opportunity to solve any building problems identified through the

owner's detailed surveys and environmental analysis. During the first 12 months, the building operators should record the conditions in the building and attempt to adjust the systems where needed if they are qualified. If they are unable to control the systems to sufficiently resolve malfunctions, the contractor should return to fine-tune the systems and equipment.

- Recommission buildings throughout their life on a regular schedule, possibly every one to two years to assure that systems and equipment are performing as intended and that the building occupants and activities conform to the HVAC system design documentation.

REFERENCES:

ASHRAE, 1996, *Guideline 1-1996, The HVAC Commissioning Process*, American Society of Heating, Refrigeration, and Air Conditioning Engineers, Atlanta, GA.

ASHRAE, 1995, *Applications Handbook, Chapter 39, Building Commissioning*, American Society of Heating, Refrigeration, and Air Conditioning Engineers, Atlanta, GA.

Code of Practice, 1986, *Code of Practice for Commissioning Mechanical Systems in Buildings*, Standing Committee of Consulting Engineers and Mechanical Contractors of British Columbia.

Ellis, 1998, *Building Systems Commissioning*, January 1998 issue of *Engineered Systems*.