The Building Commissioning/ Quality Assurance Process in North America

The commissioning process produces high quality buildings that provide comfortable and healthy conditions for their occupants

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A broad definition of whole building commissioning is evolving. Commissioning is assuming the role of quality assurance in the building delivering process. A decade ago, commissioning and system start-up were almost synonymous. The changing role of commissioning from start-up to quality assurance has its roots in ASHRAE efforts during the 1980s to respond to the then-growing problem of poor indoor air quality (IAQ).

ASHRAE efforts have included the publication of numerous documents including Position Papers on IAQ,[1,2] *Standard 62-1989, Ventilation for Acceptable Indoor Air Quality*,[3] *Guideline 1-1989, Guideline for Commissioning of HVAC Systems*,[4] and *Guideline 4-1993, Preparation of Operating and Maintenance Documentation for Building Systems*.[5]

IAQ problems have been linked to a lack of quality assurance in design, construction, operation and maintenance of buildings, specifically heating, ventilation and air-conditioning (HVAC) systems.[6-9] In 1986, ASHRAE formed a committee to address quality assurance through the development of a commissioning guideline for HVAC systems. During the development of that guideline, the committee made the decision to redefine commissioning. Rather than system start-up, the committee considered commissioning as a process for documenting and verifying the performance of HVAC systems so that the systems operate in conformity with the design intent.

Commissioning as a process is now being expanded to include the whole building, and is gaining acceptance by energy utilities throughout North America. For example, the Bonneville Power Administration (BPA) has recently defined building commissioning as,

> "A process for achieving, verifying and documenting that the performance of a building and its various systems meet the design intent and the owner and occupants' operational needs. The process ideally extends through all phases of a project from concept to occupancy and operation."[10]

A further refined definition of building commissioning was reached at a recent national conference held in Sacramento hosted by the Sacramento Municipal Utility District:

> "Commissioning is a systematic process of assuring by verification and documentation from the design phase to a minimum of one year after construction, that all building facility systems perform interactively in accordance with the design documentation and intent, and in accordance with the owner's operational needs, including preparation of operation personnel."[11]

In addition to utilities, governments are also beginning to recognize the benefits of commissioning. The State of Washington General Services Administration in September 1993 added commissioning to the Guidelines for Architects and Engineers. In the Washington State Guidelines, building commissioning is defined as,

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"The process of achieving, verifying and documenting the performance of building systems to meet the design intent and the client's functional and operational needs. It is the advancement of systems from static completion to full dynamic working order according to the specified requirements. Building Commissioning is a team effort to ensure that all equipment and systems have been completely and properly installed and put into service. The team is made up of the Commissioning Agent, Owner, Architect/Engineer, and Contractor. Commissioning is primarily part of the acceptance process. However, some commissioning activities occur during both design phase and warranty periods..."[12]

A number of observations can be drawn from these definitions:

- Consensus is converging that commissioning is a process of quality assurance that extends through the entire building delivering process.
- The need for commissioning has become evident by failures resulting in IAQ problems.
- Utilities and government agencies are spearheading initiatives to make total building commissioning "business as usual" for the building industry.

The commissioning/quality assurance process

The process of building commissioning or quality assurance begins with the pre-design or program phase of a project and follows the typical phases of project delivery: design, construction, acceptance and post-acceptance (see *Figure 1*). The following outlines the general work performed during each phase of the process.

Program phase. The front-end of the process may well be the most important. This sets the ground rules that will be followed. It is critical that the lines of communication are opened at the very beginning and all parties understand the decisions that must be made and why.

At this phase, the owner's requirements and budget are identified and, although not all team members are retained, the composition of the project team is defined. The team member with authority to coordinate the commissioning process is identified.

This team member could be a designated commissioning agent, a member of the owner's project management team, the architect, a project engineer or contractor. The team member with commissioning authority is referred to here as the *commissioning agent*. All team members must agree at this point to participate in the commissioning process and understand their roles and responsibilities during that process.

There are several important documents that result from implementation of the commissioning process at the program phase. These documents form the basis by which successful completion of the project will be determined. These documents include a program of requirements prepared by the owner and a detailed statement of the design intent prepared by the design team based on the owner's requirements and budget.

The statement of design intent should clearly define items and criteria important to the owner, to all members of the design team and to future tenants. For example, these criteria would include:

- The functional use of the facility;
- Occupancy requirements;
- Quality of materials and construction; and
- Environmental and energy management goals and requirements.

Based on the statement of design intent, the design team then prepares a *basis of design* document. The basis of design defines how the intent will be achieved in practice. In addition, during the program phase, the commissioning agent prepares a preliminary commissioning plan or outline that details the scope of the process, the time required for completion and the training and staffing requirements.

Design phase. During the design phase, the design of the building (including all components and systems) is finalized. The design is reviewed in accordance with the basis of design. Specifications and contract documents are then prepared. In addition to typical documents, the commissioning process requires that a complete description of design assumptions and criteria be prepared.

The commissioning plan and specifications are also finalized during the design phase. The commissioning plan details the activities for all players involved in the process. The plan defines the organization of staffing and scheduling. The commissioning plan is used by the design professionals to develop commissioning specifications that become part of the contract documents.

The commissioning specifications detail the commissioning process, identify responsibilities and requirements of each member of the commissioning team and detail the scope of work for all participants including contractors, vendors and the project manager. The specifications also identify the skills and qualifications of all members of the commissioning team.

The documents delivered during the design phase are:

- The commissioning phase;
- Commissioning specifications; and
- Detailed description of all building components and systems.

Construction phase. During the construction phase, all systems and components are installed, tested and put into operation.

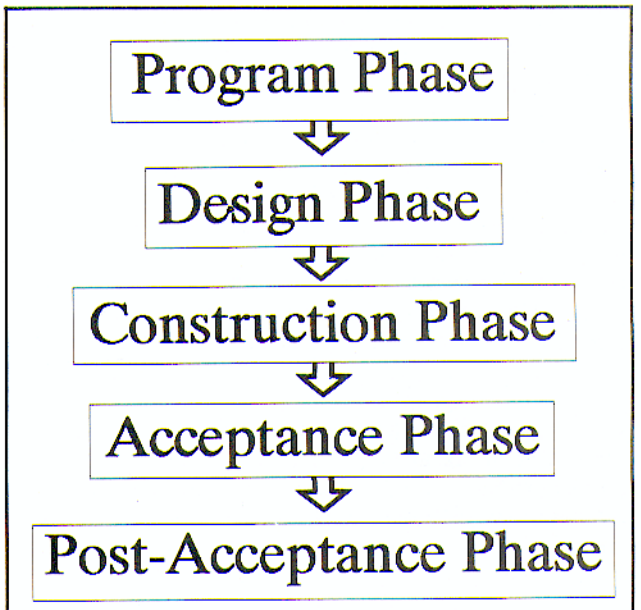

Figure 1. The five phases of the commissioning/quality assurance process.

The commissioning plan is modified to reflect all changes that are made during construction to equipment and components, as well as responsibilities within the commissioning team.

Components and systems are tested and certified ready for commissioning. All responsibilities and schedules for functional performance testing are determined. Operation and maintenance information as well as warranties are obtained for all components and equipment. Field inspections are undertaken regularly to assure that the construction complies with the documentation.

The documentation of the construction phase includes:

- An updated commissioning plan;
- Updated descriptions of all building components, equipment and systems;
- Field inspection reports;
- Component test results; and
- Pre-functional performance tests.

Acceptance phase. The result of the acceptance phase is a substantially complete building turned over to the owner. This is also usually the most important phase for the lenders, because the final draw of the construction loan is usually dispersed at this time.

Functional performance testing is undertaken during the acceptance phase to verify that total integrated systems performance meets the specified objectives. Because total building performance is a function of the integrated performance of all components, equipment and systems, during this phase it is essential to determine that all components, equipment and systems are installed correctly, tested and adjusted.

This testing is intended to document the completion and performance of all components, equipment and systems. In addition to a complete and functioning building, all documentation must also be assembled and turned over to the owner, and the operations and maintenance staff must be trained.

The documents completed during the acceptance phase include:

- Certification of readiness;
- Functional performance test results;
- Commissioning report; and
- Systems operation and maintenance manuals.

Post-acceptance phase. A building is dynamic, performance is seasonal and use changes over time. Post-acceptance phase actions are intended to respond to those changes that occur over time through the normal use and operation of a building.

As an extension of the acceptance phase, functional performance tests are continued to verify the seasonal operation of all components, equipment and systems. Procedures are set in place to document changes in use, equipment and occupancy over time and also to record user feedback. In addition, a program of periodic indoor environmental and energy performance testing is set in place.

Documents produced during the post-acceptance phase, which may span the useful life of the building, include:

- Periodic update of as-built drawings;
- Periodic update of operations and maintenance manuals;
- Log of user feedback; and
- Record of environmental and energy performance over time.

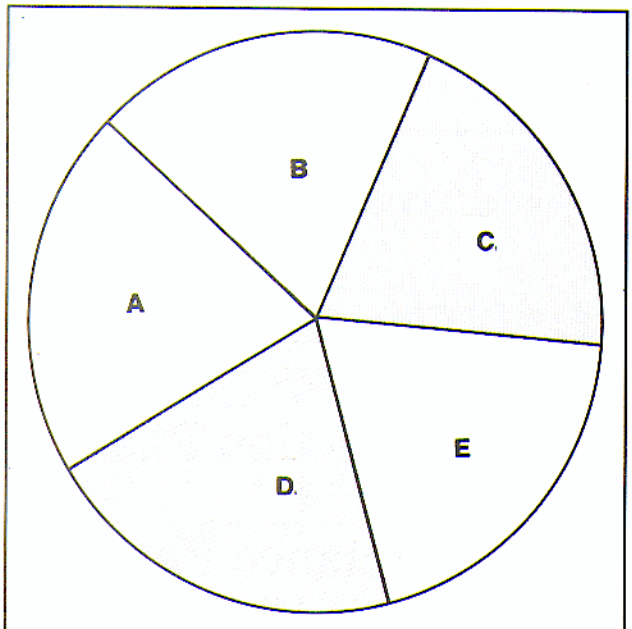

Figure 2. The members of a typical commissioning team.

The commissioning team

A typical commissioning team includes the building owner/developer, designers (architects, engineers), commissioning agent, contractors (including test and balance) and operations and maintenance personnel (see *Figure 2*). Each one of these team members has a specific set of responsibilities to assure that the process is complete.

The building owner/developer defines the overall vision and use of the building; sets operating requirements and agrees to commissioning objectives; engages the commissioning team; sets the construction budget; and determines the role of operations and maintenance staff in the commissioning process.

The owner/developer also retains a commissioning agent and facilitates communications between members of the commissioning team. However, this may alternatively be the responsibility of the coordinating design professional or contractor.

The design team documents the design intent; oversees construction activities; ensures that commissioning is included in the design specifications; reviews and approves shop drawings, mockups, and operation and maintenance manuals; reviews record drawings, control strategies and documentation; attends pre-functional performance tests and reviews test reports; reviews training materials and procedures; and recommends acceptance or non-acceptance to the owner.

In most projects, the design team is led by an architect or engineer designated as the *coordinating design professional.* In such projects, the role of the coordinating design professional is to receive and distribute information for review by the commissioning team; set a coordinating timetable; facilitate communication between members of the quality assurance team; receive and issue all final letters of acceptance; recommend acceptance or non-acceptance to the owner; and coordinate submission distribution

and hand-over of shop drawings, operations manuals and maintenance manuals.

The commissioning agent prepares the commissioning plan, test plan and final report; submits progress reports; coordinates the commissioning team and work schedules; reviews submittals; reviews commissioning specifications; attends pre-functional and functional performance tests; reviews training, materials and procedures; reviews operations and maintenance manuals; reviews record drawings and documentation; and recommends acceptance or non-acceptance to the design team or coordinating design professional.

The contractors perform work and supply equipment and systems as stated in the contracts; provide documentation as specified by the commissioning agent; coordinate quality assurance work schedules; perform pre-functional performance tests and component tests; perform functional performance tests; fine-tune and adjust equipment and systems; and provide operations and maintenance manuals and staff training.

The operations and maintenance staff define operations and maintenance requirements of the building; assist in selection of systems and controls; assist in development of maintenance manuals, record drawing and documentation requirements; assist in defining training program requirements; assist with functional performance tests as required; and attend contractor and vendor training sessions.

Cost/benefits of commissioning

Buildings are a collection of component materials, equipment and systems that must all function as an integrated whole to provide a comfortable and efficiently operating building. The cost of commissioning is a function of the complexity of the building to be commissioned.

Experience has shown the cost for commissioning new buildings to range from 0.25% to 2% of the construction budget.[13] The cost of commissioning retrofits to existing buildings or recommissioning existing buildings can be as much as 20% of the original construction budget.[14]

Conclusion

In North America, the practice of commissioning is undertaken as a quality assurance process intended to provide a building that operates as designed, that meets all the requirements of the owner and satisfies the comfort and functional requirements of the occupants.

The process of commissioning, now gaining acceptance as practiced in North America, produces buildings constructed to the highest degree of quality that provide comfortable and healthy conditions for their occupants. This process is assisting the building industry in achieving a new standard of excellence: Compliance with ISO 9000, the internationally recognized standards of quality assurance.[15]

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