

Overview of Total Building Commissioning Process

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Summary

What do you want from your construction project or new building? Do you desire energy efficient buildings? Productive buildings? Low maintenance buildings? A building that meets your needs? A sustainable facility or green building? These are some of the reasons Total Building Commissioning Process is being implemented by owners. The Total Building Commissioning Process (TBCxP) has evolved as one means to fully involve owners, operating staff, occupants, users and clients of facilities, process or manufacturing managers, design teams and contractors to achieve a quality building. An overview of the process is described in this paper to illustrate some of the best practice in delivering successful constructed projects with the TBCxP.

Introduction

The total building commissioning process (TBCxP) has evolved from various quality construction processes, including ASHRAE Guideline 1 – *The HVAC Commissioning Process* that was developed in the 1980's and 1990's. This has changed the method for planning, designing, constructing and operating buildings in North America. This paper is our view of where the best practice of TBCxP is today. The consensus express in ASHRAE Guideline 1-1996 is about eight to ten years behind “best practice” in 2000. This is very important, in that “best practice does not become documented until after a few years of implementation.

The benefits of TBCxP are buildings that meet the needs of owners and operate as expected. Owner is used as the general term to identify the person or entity that controls the project. The owner may be a company, government, design-build firm, or a developer.

Another benefit is that the design expectations and design intent are identified early and carried through operations of the building or facility. TBCxP results in lower construction costs, substantial reduction in change orders, and budget and schedules that are met or beaten. The benefit of TBCxP for everyone involved in constructed project delivery is that owners receive what they expect within their budget and owners or project managers recognize the limits of the construction project that can be delivered within a given budget.

The total building commissioning process (TBCxP) is being used as the quality process to plan and procure buildings and systems. It is commonly referred to as “commissioning” and is somewhat confusing to those who consider commissioning as only the start-up phase of construction.

The National Institute of Building Science (NIBS) is developing a set of 11 (to be eventually 18) guidelines for specific topics related to total building commissioning.

Total Building Commissioning Process

The TBCxP is a method or process for delivering buildings or facilities that begins with project inception through one or more years of operation. The process involves a commissioning authority (CxA) that represents the interest of the owner in delivering the building or facility to meet the owner’s needs. The objective is to integrate the TBCxP into existing phases and steps of building construction delivery to achieve more benefits for the owner at the same or lower cost.

TBCxP results in successful buildings that operated as expected at delivery, are economical to operate, and met occupant needs for the life of the building.

The process works well for all types of buildings, campus developments, central plants and industrial facilities. It can be used from the delivery of a single family home to the most complex building or process. The implementation will depend upon the owner’s requirements, method of building design and delivery, and size of the project. Unfortunately, many TBCxP implementations shortcut one or more steps of the process. This usually results in implementing TBCxP during the construction phase.

One of the key aspects of TBCxP is that the owner’s needs are determined during the planning and design stage, and then, well articulated in the plans and specifications. The Commissioning Authority (CxA) is a person or team that carries this message from planning and design through construction and building occupancy.

The concepts of TBCxP are rather simple. However, the implementation is not always simple or easy. The phases of TBCxP include planning, design, construction, acceptance and occupancy. There may be re-commissioning of some facilities throughout their useful life. In many cases, early re-commissioning after 2-5 years can be very beneficial. This is especially true of government projects that have long lead-time between budget programming and construction it also applies to facilities that have frequent usage changes. This includes hospitals, retail, industrial, and educational facilities.

It is essential that the TBCxP include quality provisions for continuous improvement and the development of benchmark measures to evaluate quality achievement to meeting the owner's needs. A final TBCxP report must be done in the first year of occupancy. This should include benchmark evaluations on both the building and the TBCxP. This may include: costs, quality, productivity, satisfaction, the number of change orders, punch list items, and time to complete and other benefits to the owner or users of the constructed project or building.

There are five phases in implementing a successful TBCxP. They are the planning (programming), design, construction, and acceptance and occupancy phases. Following are key aspects, tasks performed, and benefits of each phase to highlight current TBCxP practice.

Planning Phase

This is the key phase in the implementation of an effective TBCxP. The cost of TBCxP for the CxA and related services and tasks by other members of the CxTeam will be reduced when TBCxP is implemented at this phase of building delivery, rather waiting to implement during construction. The reason for this is that the commissioning process will not be developed in an orderly manner, nor the needs of owners adequately identified. Changes during construction are both costly and very difficult to implement. In addition, when TBCxP tasks have not been identified in the specifications and on construction plans they are difficult to integrate into the project. One thing that has been learned from implementing the commissioning process for HVAC and Green Buildings is that the full economic and productivity benefits cannot be achieved when TBCxP is implemented in late design or during construction. The reason is that most decisions have been made before owner's needs and design intent are fully and clearly identified and documented and that design and specifications have not been oriented for implementing construction and operations phases of commissioning tasks.

Although many of the requirements of TBCxP are identified during functional or descriptive programming (development of briefings), they have usually been approached from an architectural viewpoint. The recommended approach is to develop the TBCxP planning phase requirements prior to architectural programming or as part of the architectural programming process.

Many of the planning phase activities and results of TBCxP may be considered obvious by owners, architects and building design engineers. To some extent this is true, in that the programming and design teams have always considered most TBCxP topics. However, even with the best programming, the planning phase information has not been documented in construction documents, nor was the programming information carried through to contractors and building operating staffs to the level achieved with TBCxP.

Some key activities of the TBCxP in the planning phase include:

- Development of Design Intent (DI)
- Development of the Commissioning Plan (CxPlan)
- Preliminary Basis of Design (BoD)

The details of each of these will vary with owners and the approach of the commissioning process team. Following is a brief review of Design Intent to illustrate how it fits into the quality delivery process.

Design Intent

The owner and the CxA can develop the design intent, with occupants, customers, operating and maintenance staff as primary participants. This can be developed through an owner's workshop, through interviews, or use of surveys.

In some cases, all of these may be used. This is especially true for innovative buildings and systems. This includes sustainable designs, unique designs, thermal storage, innovative educational facilities, hospitals, and industrial environmental processes. The use of more than one method can provide input from individuals that may not be able to participate in a single form. There are usually some individuals that we need interview prior to doing the formal interviews, surveys or design intent workshops. Owners that use the same design team or contractor on all or most of their projects will want to include the design team as a valuable member in developing design intent. It is highly suggested that owners consider the use of a design intent workshop with an experienced CxA on the first project they implement the TBCxP. This allows the owner and all other participants to fully understand the TBCxP and to set realistic goals. The design intent is usually developed simultaneously with TBCxP goals. Both are used to develop BoD and the CxPlan. The DI includes information that must be considered and addressed in the design, basis of design and included in the specifications or on the plans to insure the DI of the owner is met. The DI and BoD are stated on the construction plans or in the construction manual. If these change during design, construction and operation of a facility, they must be continuously updated.

It is very important to the success of the TBCxP that this is addressed early and not compromised. It is a very important aspect of full team participation and continuous understanding of the owners needs for the project. This is one of the key contributions to achieving a building that is delivered to meet the owners needs and satisfaction. Keeping this information secret (in a file or as CxA's knowledge) does not benefit the quality or success of the project. Further, any future changes to a building's use will be much more economical and effective if the DI and BoD are on the construction as-builds. This prevents re-design and cost to future improvements, upgrades, and change out of equipment or re-commissioning.

The owner's goals (OGs) related to the implementation of TBCxP are frequently very close to DI requirements and are usually included in the list of DI requirements on the construction specifications. The design intent should be included on the section of the plans in which they apply. There may be some DIs and OGs that are included on the first general section of the plans. If all are to be summarized in the first section of the plans or recapped in the specifications, there needs to be an accurate track of changes implemented to prevent changes in one section or document without the related change being made in the summary section.

Some design intent examples are:

- maximum use of recycled material in the parking surfaces
- meet ASHRAE standards 62 and 55
- achieve 93% satisfaction during occupancy on all comfort surveys
- achieve less than 8% dissatisfaction on all IAQ surveys
- achieve a 15% increase in sales or productivity as compared to the existing building
- satisfy variance needs of individual
- have all surfaces and materials that can be cleaned with non-hazardous chemicals, water and soap cleaning preferred
- full communications access (or outlet) to meet needs of next 10 years
- fully integrated building maintenance, security, building automation, communications and data networks

Examples of owner's goals (OGs):

- reduce change orders by 90% from average of last 10 projects
- no required changes during first year of occupancy
- reduce occupancy punch list to less than 10 items
- no additional cost to achieve a quality building

- reduce operating and maintenance costs by 25%, compared to last three equivalent buildings
- fully trained building staff, janitorial, maintenance and repair technicians
- all plans, specifications, shop drawings, maintenance-repair-operation manuals and instructions provided in electronic, searchable format
- a systems manual that gives sectional overview and explanations of all building components and systems, to be used as an introduction to new employees or associates and to service contractors

Basis of Design

The basis of design is the information and approach the design team uses to achieve the owners design intent and goals. In addition, there are a number of basis-of-design that should be listed on the construction documents, which are not related to specifically listed TBCxP requirements.

This formal documentation is an important aspect of a successful TBCxP for an owner, design built provider, or in-house construction group. By documenting the basis of design we have information that can be reviewed by everyone to provide input for continuous improvement of the TBCxP. Frequently a preliminary basis of design information will be included in the preliminary CxPlan developed during the planning phase.

Some basis-of-design (BoD) examples are:

- JobOne Do's and Don't lists (desires)
- State Guidelines on Energy
- Standard 102
- Weather data for ThisTown
- BestMfg green materials data

Commissioning Plan

The commissioning plan is a living document that is important to successful implementing the TBCxP. This plan is used to document the TBCxP program, who is involved, role of each CxTeam member, schedule, design intent, owners program, owners design guidelines, basis of design and overview of the project.

The initial CxPlan is developed during the planning phase. The CxA almost always develops it. It should be the responsibility of the CxA to insure that the plan is continuously updated through design, construction and first year occupancy to reflect actual construction and installed systems.

The plan should be expanded as required to allow a sample document for future building projects. The CxA provides a valuable service for continuously improving the TBCxP for specific owner and to transfer the knowledge to future projects by others. A commissioning plan should have specific sections for planning, design, construction, acceptance, and operations phases. In addition, it should have sections on training, acceptance testing, systems manual, and owners program. An effective cross-reference between sections needs to be developed. Checklists of tasks and timelines of each member of the CxTeam are useful. This can assist each team member and can be used by the CxA to insure quality needs are being met.

Design Phase

The commissioning process provides valuable information for the design team. This should be fully documented in the preliminary CxPlan. The information allows the design team to concentrate on design approaches for the architectural aspects of the building and engineers to concentrate on an effective design that meets the owner's needs. It should eliminate the requirement for alternative system evaluation to determine what the owner desires.

The CxA role in the design phase is to review plans for the owner, to insure that design intent is achieved and that construction requirements related to design intent and owner's goals are included in the construction design documents.

The commissioning role of the design team is to include clear and complete information to insure the contractor fully understands and is able to implement requirements for the commissioning process.

Key elements that should be addressed by the design team are:

- training requirements
- materials approval
- materials and system testing
- functional performance testing
- commissioning checklists
- materials, equipment and system checklists
- commissioning quality requirements
- consequence of rejection or failure to meet needs
- inspection schedules, who and when
- commissioning meetings
- punch lists
- change orders

- warranty period requirements
- acceptance procedures

Incorporating TBCxP into your first project is a major task and fees should be allocated to insure it is done completely and without problems during construction. It must provide documentation that is clear to this new approach for quality delivery of buildings and facilities. The contractor is the construction expert and must be a key member of the team and TBCxP.

Construction Phase

If all requirements are well thought out and described in the construction documents, the construction phase goes very smooth. The contractors, vendors, and manufacturers are the only people who can achieve the delivery of a quality building. The role of the TBCxP is to assist everyone in the construction phase in reducing tasks and work that does not add to the quality of the building or owner's needs, which would otherwise only add costs to material suppliers, equipment manufacturers and contractors, including rework without adding value to the project.

With the additional planning and documentation through the TBCxP in the planning and design phases it is possible to eliminate all re-work, reduce unknown or uncertainty for the contractor and prevent surprises to the owner, designers and contractors during the construction phase. Essentially the TBCxP allows a very focused set of plans and specifications and clear requirements on inspection of construction work, training and system manual needs. There is substantially less uncertainty on the soft aspects of the construction process.

In addition, the CxTeam can insure that construction is continuously reviewed to achieve high quality without any unnecessary burden on the contractor. This includes training requirements, inspection delays, and early involvement of testing subcontractors and manufacturers. Essentially the TBCxP allows contractors to achieve a higher quality at less cost and more profit.

Acceptance Phase

This is not strictly a separate phase of the building delivery process. However, it has been developed as a set of specific tasks related to the commissioning process and the phase in which the building or systems are accepted. This includes performance testing, fire system verification (for example the requirements ASHRAE Guideline 5), testing and balancing, final punch list development, code official inspections, obtaining certificate of occupancy and related tasks that are not completed by construction crafts and technicians. It will include requirements after the building is substantially complete and occupied.

These acceptance phase tasks include seasonal testing, training identified after several months of building systems operation, or end of warranty validation requirements. It can include owner's needs that are specified in specifications for acceptance at a time after the end of construction. An example is a requirement to meet a desired performance level for energy or operating costs. The scheduling and clearness of acceptance phase tasks are very important to the satisfaction of a delivered building. It provides the information on what was delivered and information for the owner for successful operation and maintenance of all building components and systems. The acceptance phase is especially important to innovative and unique buildings, such as sustainable buildings and cool thermal storage systems. In some cases the acceptance phase may include training and developing of the system manuals.

Occupancy Phase

The TBCxP usually extends into the first year of occupancy. For industrial facilities and processes this frequently lasts for three years. This involves the knowledge of the CxA through this one year period to assist the operating staff, owner, and service contractors to provide an economical delivery of a the construction project or a new building. An important requirement of this phase is the development of the TBCxP report. This may include a preliminary report at the end of construction and a final report at the 8-12 month of occupancy. A report has three goals:

- a record and evaluation of the benefits of the TBCxP
- a record of information that has not been previously recorded to assist the owner and operating staff to effectively operate and maintain the constructed project or building
- a report for use in improving the TBCxP for a specific owner (this is part of the continuous improvement recognized as essential to total quality management)

The final report may develop benchmark information on the building in general and the TBCxP. This may include: costs, quality, productivity, satisfaction, the number of change orders, punch list items, time to complete punch list items, and other benefits to the owner or users of the constructed project or building.

Dual Commissioning Authority

One of the key benefits the TBCxP for the owner is the representation of the owner's interest by the CxA from planning through operations. This provides a person or team that understands the TBCxP and the needs of the owner and can convey these through design, construction, acceptance and first year of operations. The CxA can be an employee of the owner. This is common for organizations that have a large number of construction projects.

The CxA needs to have some expertise in design, construction and operation of buildings. Since, there are substantial CxA effort during construction and acceptance; it is sometimes, if not always effective to have two levels of CxAs. One is the owner's commissioning authority (CxA) and the other is the general contractor's commissioning authority (CCxA).

This allows a substantial amount of the construction phase CxA and CxTeam tasks to be included in the specifications as contractor requirements. Some owners have been successful in providing a list of approved contractor commissioning authorities that can be used by the contractor for a specific project. This approved list becomes somewhat like the approved list for equipment. The owner usually has a one to two-day training session for those who desire to be CCxAs.

This use of dual commissioning authorities has two advantages. It puts the responsibility for much of the routine construction commissioning tasks with the contractor. This allows close coordination of commissioning process tasks with construction. It places control of achieving quality with the person who must question, stop, or reject work or equipment as an employee of the general contractor or as a sub-contractor to the general contractor. It allows this person or group of people to be at the construction site for regular implementation of commissioning tasks.

With this separation of commissioning process, the owner's CxA can concentrate on the implementation of the TBCxP, develop statistical tools to verify quality, assure that design intent is achieved, and the project is constructable and maintainable. The CxA is still responsible for leading the CxTeam in developing checklists and methods for task verification, training requirements or plans and methods to verify completeness of system manuals and as-builds.

The advantages of dual commissioning authorities is that each commissioning authority can do the tasks in which they are best qualified and remove the conflict between a person or team that does not have direct responsibility to the general contractor for the day to day commissioning requirements. This works very well for design-build projects as well, since the same division of expertise usually exists in design-build organization.

Benefits of Team Members

The bottom line for implementing the TBCxP results in benefits that are not achieved without the TBCxP. The benefits will vary with projects and owners. However, some of the benefits that have been noted on projects are listed below for various parties.

Owners

- has more involvement in early planning of project needs and function goals to be achieved
- has a person or group that represents the owner's needs through the design, construction, acceptance and occupancy, versus passing this responsibility and knowledge from one unity to another
- means to evaluate and benchmark projects
- substantial reduction in change orders (typically 80-95%)
- few punch list items at occupancy (typically reduced by 95% or more)
- buildings and building systems that work
- allows implementation of innovative projects (i.e. Green Building) with low risk of failure
- implementation of effective quality processes
- able to effectively implement ISO quality standards
- higher profits through an effective and productive project or building
- gets a report on project quality, through the final TBCxP report

Design Team

- receives higher quality and targeted information on all aspects of the construction project or building
- able to clearly specify what is required to achieve quality
- means to convey acceptance
- gets the building they intended in their design
- able to transfer the design basis, concepts and thought process in the construction documents
- a second team member to assist with meeting the owner's needs
- able to design the actual building that the owner wants, not an uncertainty of owner's needs
- less involvement in construction, acceptance and occupancy issues that are handled by the commissioning authority or team
- able to work as a team member (commissioning team) to achieve cooperation during all phases of project delivery
- few call backs during the first year of occupancy or warranty period (when it is more than one year)

- higher profits
- gets a report on project quality, through the final TBCxP report

Contractors

- can be involved in making changes and controlling the process for achieving quality
- reduced re-work
- has access to a representative of the owner (CxA) to resolve issues and reduce scheduling delays
- reduced finger pointing
- able to work as part of a quality team (CxTeam) versus reaction without input
- few call backs during the first year of occupancy or warranty period (when it is more than one year)
- higher profits
- gets a report on project quality, through the final TBCxP report

Operating and Maintenance Staffs or Service Contractors

- given opportunity to have early planning phase input on needs
- involved during construction as a member of the Cx Team
- allowed to tailor training to their needs
- receive system manuals that are effective, especially electronic versions
- have a single person or organization (the CxA) to contact for all requirements during the first year of operations and maintenance of the project or building
- able to have the CxA as a representative of the owner to resolve problems

Users of the Project or Building

- higher profits
- increased sales
- higher satisfaction of customers and visitors
- higher employee or associate satisfaction with the project or building
- increased productivity

Conclusion

Several private and government organizations have implemented the practice of TBCxP. It is typically implemented for selected building components and systems, instead of all aspects of construction. There are a few cases where it has included almost all of the design and construction components. This is especially true for Green Buildings, campus type developments, and industrial processes.

TBCxP is a process that begins at building inception and goes through occupancy. The process provides economic benefits that are greater than the implementation cost. NIBS' guidelines for TBCxP should make it much easier to implement and promote the TBCxP. It will be easier to sell to owners and provide a more uniform means to implement TBCxP by owners and CxAs. The current development of model guide specifications to include commissioning process needs will also improve the uniformity of quality application of the TBCxP. We are at the beginning of a better means to delivering quality and cost effective buildings through the Total Building Commissioning Process.