

Overview of Total Building Commissioning Process

Carl N. Lawson

Member ASHRAE

ABSTRACT

A key phase of the total building commissioning process (TBCxP) is construction. It is critical that during construction that the individual workers are aware of the owner's requirements and that their work will be verified. During construction the commissioning authority acts as the owner's representative in verifying the work being completed, assuring proper documentation is being maintained, and that the building is 100% functional the day the owner occupies it. The benefits achieved during the construction phase of TBCxP include reduced change orders, on budget/schedule, properly trained staff, and reduced callbacks for the contractor.

INTRODUCTION

The construction phase of the commissioning process starts when the contract documents have been sent to the contractors to obtain their bids and continues through to the acceptance of the building by the owner. The primary goal of commissioning during the construction phase is to ensure the contractors provide a building that meets the owner's requirements – the design intent.

<p>Carl N. Lawson is a Construction Administrator for Duke University Medical Center located in Durham, North Carolina.</p>

The primary commissioning phases during the construction phase that are accomplished include:

- Pre-bid
- Pre-construction
- Construction
- Turnover

PRE-BID

The primary role of the commissioning process prior to the acceptance of bids is to ensure that each of the contractors who are participating in the project has been notified that commissioning will take place and that their areas of responsibility are detailed in the construction documents. This includes advising the contractors that commissioning is to take place and will be an integral part of the project, and that the various sub contractors are an essential part of the process.

Before the project bids are accepted, the commissioning authority holds a pre-bid conference to advise the potential contractors that commissioning is to be used. In this conference the commissioning authority outlines the responsibilities of the various contractors and presents a draft-commissioning plan for discussion. Also, the design intent and the contract documents are reviewed so all potential contractors understand the goals of the project. This will help the contractors prepare their bids and properly allocate resources for commissioning tasks.

It is of the utmost importance that the commissioning authority assists the owner and the design team in selecting the construction team, for they are to live and work together for the duration of the project. The owner should seek resumes of the various project managers, superintendents and foreman for each trade. The owner should also contact those listed on the client list and references for the contractors and sub-contractors to gain a level of confidence that the entire team can work together.

PRE-CONSTRUCTION

The primary tasks accomplished during the pre-construction phase include a pre-construction workshop, team building and submittal review.

Pre-construction Workshop

The pre-construction workshop should be held within 45 to 60 days of contract award. The intent of this workshop is to review the commissioning requirements and to aid in the team building of the individual contractors, A/E, commissioning authority, owner, O&M personnel, and manufacturers. During this workshop the Commissioning Authority:

- Reviews the commissioning plan and discusses what it will entail and how each team member will have a part to play, such as: testing and documenting tests and procedures
- Discusses the submittal process and the importance of correct and concise submittals
- Illustrates the types of documentation that are required and responsibility of the contractors
- Demonstrates the use of any tools that are available and they way they will be utilized
- Reviews codes and standards and how they will be interpreted and enforced

- Reviews schedule development requirements and updating procedures

Team Building

A key role of the commissioning process is to build the cohesiveness of the team. This is best accomplished by individually meeting with the various sub-contractors to put them at ease with the commissioning process. This is typically required because, for the most part, the commissioning process is new to them and they want to make it more difficult than it has to be. During these individual meetings, discuss quality control and quality assurance procedures they commonly use and how commissioning can aid in these tasks. Assure them that they all will benefit from this process.

When the contractors or the owner hold teaming or partnering meetings, it is critical that the commissioning authority be involved. Ensure that the agenda includes time to discuss commissioning and how it relates to the project, question and answer period, and sufficient breaks for everyone to get to know each other better. Be sure that everyone signs off on the Project Mission Statement and that it is prominently displayed where everyone can see it on a daily basis.

Submittal Review

A key task to be accomplished during the pre-construction phase is review of the contractor's submittals. This includes both shop drawings and construction schedules. The commissioning authority's review of the submittals occurs concurrently with the design team to help speed up the review process. The commissioning authority's review should focus on ensuring the owner's design intent is being met; is the equipment being submitted what was specified or are the vendors trying to get other equipment approved that will not be maintainable

or will not provide the same characteristics of the design. In addition to checking the quality of the contractor's submittal, the commissioning authority also verifies the quality of the A/E's review process. Unfortunately, this is required due to a growing trend that the person reviewing the submittals in the design office is not the designer, thus resulting in major problems.

In addition to the shop drawings, the commissioning authority also reviews the construction schedule to verify that all commissioning activities are included in the overall construction plan. If not properly integrated, it is the commissioning authority's role to outline to the contractor how commissioning relates to the project and how critical it is that the schedule properly reflect the commissioning requirements.

CONSTRUCTION

During the construction sub-phase, the four main tasks to be accomplished are:

- Meetings and schedule
- Verification
- Logs
- Training

Meetings and Schedule

Throughout construction there is typically the need for periodic commissioning meetings. While these meetings can be held at any time, our experience has shown the best time for these meetings to be the day before the contractors regularly scheduled progress meeting. The focus of commissioning meetings is to verify the schedule is being maintained issues relative to the design intent identified, and coordination problems resolved. By having the meeting prior to the progress meetings, problems and praise of contractors can be identified and then resolved or forwarded to the progress meeting for additional discussion.

Beyond the meetings, the commissioning schedule, along with the overall construction schedule, must be reviewed on a weekly or monthly basis. This primarily focuses on working with the contractor's scheduler to keep the schedule updated, current, and accurate.

When reviewing the schedule, specifically update and monitor all equipment delays and schedule changes. The overall schedule must reflect these delays and changes and why they are occurring. All delays and changes must be documented and reported to all parties to avoid unnecessary or unwarranted claims. Since the construction schedule is a moving target, it is better to control it than it control you. The commissioning authority has tremendous input to help maintain the original schedule.

Verification

The key role of the commissioning authority during the construction sub-phase is to verify that the construction meets the owner's design intent and level of quality. In addition to off-site activities, such as factory witness testing, the commissioning authority verifies all of the commissioned systems. This is typically called verification or verification testing.

Since the contractor is responsible for meeting the specifications and installing quality systems, the commissioning authority's responsibility is to ensure that this is accomplished. Using quality assurance tools from industrial settings, the commissioning authority randomly samples the built systems (envelope, structure, mechanical systems, lighting, etc.) for acceptability. If problems are found, it is the contractor that is responsible for accomplishing 100% checking of all systems. This approach puts the responsibility back on the contractor for quality and simplifies the commissioning authority's scope. Some of the items typically verified on a project include:

- Verify all equipment meets the specifications and is it installed as designed or per approved change order
- Verify all code issues have been met
- Verified all RFI ramifications/ questions have been resolved
- Verify all coordination drawings were followed
- Verify all deficiencies and other concerns have been corrected and documented
- Verify controls are functioning and controlling as specified or approved
- Verify record drawings and system documentation is accurate

Logs

The commissioning authority keeps a daily log of all commissioning activities. This includes all correspondence, phone messages or and similar paperwork. The daily log is also a place to identify and track the resolution of all issues. A typical issue log should include the issue, who is responsible, when is a response required, and what are the consequences of not fixing the issue. The consequences should include costs to the owner and all contractors. These

logs aid in keeping an open line of communications with all of the contractors on the project between the owner, the architect, engineer, and the vendors.

Training

Early, typically within 60 days of shop drawing approval, the O&M manual is required from the contractor. This is to ensure that the O&M manual is of the level of quality desired by the owner and that the O&M manual can be used as a training tool throughout construction.

Training of the O&M personnel occurs throughout the construction process and through the first year of operation of the building. The commissioning authority, in conjunction with the O&M personnel, develops detailed training agendas. These agendas are then provided to the contractors so they can identify the appropriate trainer and to develop the training materials for each training session. Training is typically a mixture of classroom training, site walk through and off-site training. The goal is to ensure the O&M personnel can properly operate and troubleshoot all building systems from day one. This is accomplished by spreading the training over several months and getting the O&M personnel involved in walk through of the site during construction so they can see where equipment is placed and how it is supposed to operate.

The key to the training is to focus on systems and not just components. Therefore, instead of chiller training, the chilled water system is trained as a whole. This provides the O&M staff with focussed information on how to operate and optimize the systems, not just components. A major part of these systems training is the documentation and presentation of the approved sequence of operation

Prior to contractor training, which is typically presented by the manufacturers, the commissioning authority presents a session on the design intent and the A/E presents a section on the basis of design. The intent of these two sessions is to provide the O&M personnel with

basic information on why and how the system was designed the way it was. Therefore, they can ask more focussed questions and have a better understanding on how to optimize the various systems.

TURNOVER

The construction sub-phase is complete when the control system has been verified (calibration, point to point testing, and individual control sequences are functioning properly) and the TAB report has been verified for accuracy. At this point, all systems are functioning and the building should be ready for occupancy. However, before the building is given to the owner, several items must be accomplished to ensure the owner is ready to take it over. In addition to systems training and the receipt of the final O&M manuals and record drawings, the building must be functionally tested.

Functional performance testing is the documentation and verification that the commissioned systems perform according to the design intent and basis of design. Typically, this is accomplished by running the various systems through all normal and emergency modes of operation. This can include:

- Verify the overall operation of the system as a complete and integrated system
- Make the control system do all the things it was designed to do and some it was not to do – try to find means and methods to make the system fail
- Verify the fire alarm system and all interfaces
- Take system off main power and verify emergency system operation
- Place back on main power and verify overall operation

The process of testing requires detailed data from the manufacturers and the use of the commissioning authority's own experience. You may have had a good or bad experience with a

certain piece of equipment. Regardless of what the manufacturer says, rely on your experience, but you should share your experience with the design team and others include the manufacturer.

Similar to verification testing, functional performance testing is typically not accomplished on 100% of the systems. Using random sampling will identify areas of concern that can then be addressed in all of the systems. If no problems are found in the sampled systems, then there is a high confidence that the remaining systems are at just as high of quality. Also, even sampling 100% of the systems will not identify all of the errors since we will always miss something. However, some owners require 100% sampling to provide them with a better feeling. Typical sampling rates used at Duke University Medical Center are:

- 10% of Air Handling Units
- 100% of Chillers and Boilers
- 100% of Fire Alarm and Smoke Purge Systems
- 20% of Variable Air Volume Systems including duct work
- 10-30% of Test and Balance
- 10-20% of all Pumps
- 100% of Cooling Towers
- 50 – 100% of Building Automation Systems

CONCLUSION

The information presented on the construction phase of commissioning is only the result of significant efforts by the commissioning authority during the planning and design phases to ensure the owner's design intent is known and that the design meets the owner's requirements.

In the construction phase the following should be adhered to for a complete and functional project:

- The commissioning authority must be contracted directly to the owner
- Review all documentation
- Review all test procedures
- Document the entire project
- Schedule and run the commissioning meetings
- Participate in all construction progress meetings
- Video the entire process for owner future use, with this it gives the owner the opportunity to continually train and educate his operations staff