Elements of Commissioning Architectural Systems

Tony Martin
WorkingBuildings, LLC

Synopsis

The building envelope is a critical design consideration for any building. Because the building envelope is typically not viewed as a system, it is often overlooked in the commissioning process. However, the functionality and performance of a facility is highly influenced by the performance of the components of the building envelope such as the air and vapor barriers, glazing, insulation, drainage planes and external environmental considerations. These components can greatly affect the Indoor Environmental Quality by preventing the microbial growth within the envelope, limiting infiltration of outdoor air, controlling humidity, enhancing the work environment, and reducing energy use. The building envelope system is key in the successful performance of all building systems. The failure of the building envelope to function optimally affects the ability for other systems to pass the functional performance test.

Applying the commissioning process to the building envelope system can help ensure proper design, installation, and function. This paper will show how all phases of the commissioning process should relate to the building envelope. Specifically, Owner's Performance Requirements (OPR), Basis of Design (BOD), design reviews, submittal reviews, pre-functional checklists, periodic site visits, functional performance tests, seasonal testing, and warranty reviews will be discussed.

About the Author

Tony Martin began his career as a project engineer and a project manager for a design/build mechanical contractor. There he designed and managed the installation of all types of mechanical and plumbing systems. Tony has spent the past four years working as a commissioning authority for WorkingBuildings, LLC headquartered in Atlanta, Georgia. Tony has millions of square feet of commissioning experience including projects ranging from small tenant improvement projects to large data centers, central energy plants, and high containment laboratories.

Introduction

The building envelope acts as the skin of a structure. It provides a barrier between the indoor environment and the outdoor environment. The building envelope has four major objectives: structural integrity, moisture control, temperature control, and control of air pressure boundaries. The failure of the envelope to perform any of its prime objectives can lead to serious problems inside the building. Problems that result from failed building envelopes include poor indoor environmental quality, encouraged mold growth, loss of temperature and humidity control,

The commissioning process will help the designers and contractors improve the quality of the design and installation of the systems. The goal of commissioning is to verify and document that the facility design and construction meets the Owner's Performance Requirements. Properly applying the commissioning process will help detect issues early in the process when they are relatively inexpensive to correct.

Key Envelope Systems

There are many different types of envelope systems including vapor barriers, drainage plains, air barriers, glazing systems, doors, slabs, roofs, etc. For the purposes of this paper, special attention will be paid to drainage planes and vapor barriers. The reader should keep in mind that the concepts explained here can be applied to any building system.

When discussing drainage planes and vapor barriers, it is important to realize that their primary function is to keep water out of the facility. Water has four basic forms: solid, liquid, vapor, and adsorbed. This paper focuses primarily on the liquid and vapor forms of water.

Drainage Planes

The concept of a drainage plane is simple. Liquid water, in the form of rain, will attempt to enter the building during a storm event. The function of a drainage plane is to direct the liquid water down and away from the building. Many different materials are used as drainage planes, the most common of which is tarpaper or building paper. The drainage plane is installed behind the cladding (brick, stucco, siding, etc.) and behind an air space. It is important to note that most drainage planes do not prevent air or vapor from penetrating the envelope.

Vapor Barriers

The basic function of a vapor barrier is simple: keep vapor out. However, correctly designing and installing a vapor barrier to accomplish this function is very complicated. The complication arises from the number of variables that must be considered. These variables include material permeability, hygrothermal climate (see Figure 1), and other construction materials within the wall assembly.

Figure 1 – Hygrothermal map of North America[1]

Applying the commissioning process to the building envelope

Commissioning is a quality assurance process that can be applied to any building system. Historically, commissioning was a process used by contractors to assist with HVAC equipment start-up. Over time, the commissioning process has grown from HVAC start-up to a total building commissioning process that starts at the pre-planning phase and continues throughout the life of the facility. The intent of the following paragraphs is not to explain the commissioning process in detail, rather to show how the commissioning process can be applied to the building envelope. To learn more about the commissioning process, refer to ASHRAE Guideline 0-2005.

Owner's Performance Requirements (OPR)

The OPR is a document that outlines the success criteria for commissioning. The contents of the OPR range from very broad goals to very specific parameters. An example of a broad goal is,

[1] "*Understanding Vapor Barriers*" by Lstiburek, J. *ASHRAE Journal*, 2004.

"No punchlist at turnover." An example of a specific parameter is, "Laboratory maintained at a pressure of -0.005 in.wg in relation to the adjacent corridor." Both of these types of statements provide the commissioning authority with valuable information about the owner's goals. The statement of having no punchlist at turnover tells the commissioning authority (CxA) that the owner will not occupy the building until all items are complete. This can be accomplished by providing detailed construction checklists (discussed later) or by ensuring there is plenty of time at the end of the schedule for testing and punchlist correction. The statement about keeping the laboratory at a specific negative pressure tells the CxA that there will be special requirements of the building envelope in that area. The CxA will need to ensure that the designers have captured this requirement in the design not only with the HVAC system but also with the envelope system. Things like exterior wall air barriers or cavity pressurization systems may be required to meet this parameter.

It is important to formally document the owner's requirements. There are many ways to accomplish this. Nominal group technique workshops, interviews, and surveys can be used to gather the required information. The method used will depend on the size and complexity of the project.

Basis of Design (BoD)

ASHRAE defines the Basis of Design as "a document that records the concepts, calculations, decisions, and product selections used to meet the Owner's Performance Requirements… The document should include both narrative descriptions and lists of individual items that support the design process."[2] The Basis of Design is the CxA's first opportunity to see the designer's vision for the facility. The CxA should take the opportunity to review the BoD to ensure the designers have clearly explained how the envelope will be constructed. What type of drainage plane is being provided? Will the slab have a vapor barrier?

The CxA should verify the following are clearly outlined in the Basis of Design:

- A description of the drainage plane. Which materials to use and how they will be installed should be clear in the BoD.
- A description of the vapor barrier. What material will be used and what is its "perm" rating? Where will it be installed, on the inside or outside of the building insulation?
- How will the air space behind the cladding be drained and vented?
- Is an air barrier required? If so, how will the air barrier be accomplished?

Keep in mind that the goal is to catch and correct issues as early as possible. The above list is a sample of items to consider. A more thorough list of items should be developed for the project taking into consideration the size and complexity of the facility as well as the scope of commissioning.

[2] ASHRAE, 2005. *ASHRAE Guideline 0-2005. The Commissioning Process.* American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA

Design Reviews

In a perfect world, on the perfect project, the CxA will review all of the design documents including:

- Schematic Design
- 50% Design Development
- 100% Design Development
- 65% Construction Documents
- 95% Construction Documents

In reviewing the Basis of Design, the CxA verified that the envelope systems were described appropriately considering the project location, facility type, and the Owner's Performance Requirements. During the design review, the CxA can review the documents to ensure sufficient detail is provided on the drawings and in the specifications. All of the assembly details should be reviewed against the OPR and BoD. Also, the review should verify there are no conflicts or ambiguities in the assembly details. Constructability should also be considered during design reviews. Is there sufficient detail for the contractor to properly build the system or are there uncertainties that can lead to requests for information (RFI's) and/or change-orders?

Submittal Reviews

The submittal review phase gives the engineer and CxA a chance to review the contractor's proposed material selection prior to purchasing or installing. Building envelope submittals include product data for drainage plane materials, vapor barrier materials, windows, doors, etc. The submittal review should verify that the proposed materials will perform to meet or exceed the design.

It is important to note that the CxA should review submittals concurrent with the design team and owner in order to maximize the value of the review comments. If the CxA has a comment that could potentially cause the engineer of record to reject a submittal, its best done as early as possible to avoid costly construction delays.

Pre-functional Checklists

When commissioning the envelope system, the CxA should develop detailed pre-functional checklists (referred to as "construction checklists" in ASHRAE Guideline 0-2005). The purpose of the checklist is to help the contractors do work properly the first time. Checklists are intended to supplement, not replace, the design drawings and specifications. Using quality checklists has several advantages:

- Gets the information from the design drawings and specifications to the contractor in simple, easy to understand language
- Helps contractor understand quality expectations
- Helps CxA, owner, and engineer track construction progress

A good checklist has the following attributes:

- Questions are in "Yes / No" format
- The correct answer is "yes". "No" indicates a deficiency
- Questions are specific
- Avoid terms such as "is item installed per specifications?"

See Table 1 for some example questions pulled from a pre-functional checklist developed for a slab vapor barrier system.

Table 1 - Example questions for a slab vapor barrier

Number	Question
1	Is the vapor barrier polyethylene with a minimum thickness of 10 mil.?
2	Are vapor barrier layers installed with 6" of overlap?
3	Are edges sealed with tape along entire length of lap?
4	Are edges turned up to within 1/2" of top of slab?

Site Observation Visits

Periodically throughout construction, the CxA should perform site observation visits. The intent of these visits is to verify system installation is in compliance with the contract documents and will meet the OPR. During the site visits, the CxA should document that the proper installation procedures are being followed and the proper materials are being used. Photographs should be taken as documentation before the work is covered up with the exterior cladding. Deficiencies should be reported immediately in a site observation report and the resolution of issues tracked in the issues log. This is the last chance to catch issues before they are covered up and correction is more difficult and costly.

Functional Performance Tests

Functional performance tests should be performed when construction of the system is complete to verify the system operates as intended. Some test conditions can be difficult to simulate. For example, how can you simulate a windy, rainy, hot day? If possible, let nature do the hard work. Perform the testing on a rainy day to check for leaks. Use fans to simulate wind or create a pressure differential. Use a hose to simulate rain if needed. It may also be necessary to defer certain tests until the appropriate weather conditions are available.

Seasonal Testing

It is always a good idea to repeat some of the functional tests in the opposite season as the original test. For example, vapor barriers can have a much more difficult job to perform on a sunny day in the summer versus a mild winter day. The sun can heat up the air space between the cladding and the barrier that will in turn raise the vapor pressure in the air space. Since vapor wants to travel from high pressure to low pressure, the result will be greater load on the vapor

barrier. Also, materials expand and contract as they heat up and cool down. This will introduce stresses on materials that were not present during the original testing.

Warranty Review

The commissioning process does not end when construction finishes. A typical commissioning contract lasts through the first year of occupancy of a building, also known as the warranty period. The CxA responsibilities during the warranty period include:

- Tracking issues during the first year
- Perform seasonal and/or deferred testing
- Follow-up on open construction issues
- Conduct lessons learned workshop
- Review operation of facility with maintenance staff
- Provide the final commissioning report.

It is important to continue to track new issues as they arise during the first year. The CxA should be informed of all issues during the warranty period so that they can be tracked along with construction issues in the issues log. This will give the building owner a good picture of the system and its issues from design through the warranty. Also, if a system has several issues during the warranty, the CxA can help provide documentation to justify an extended warranty.

In many cases, the owner will take occupancy of a building while there are still open issues on the punch list. In this case, the CxA should continue tracking issues until they are resolved.

During the first year, it is important to have a lessons learned meeting. The intent of this meeting is to get all of the parties together after the project is complete to discuss things that went well and things that could be improved. Representatives from the design team, contractors, owner, maintenance staff, user groups, and the CxA should be present. The CxA should conduct the meeting and provide a report to the attendees.

Conclusion

Commissioning is a quality assurance process. The goal of the process is to ensure systems meet the Owner's Performance Requirements and to catch issues early when they are relatively inexpensive to correct. Because commissioning is a process, it can be applied to any system within a building. Applying the commissioning process to the building envelope follows the same steps as with any other system. In summary, the commissioning process includes the following steps:

- Develop the OPR
- Verify the Basis of Design meets the OPR
- Review design submittals to verify compliance with the OPR and Basis of Design
- Develop prefunctional checklists and functional performance tests
- Perform periodic site visits to verify installation
- Perform seasonal and deferred testing

- Perform first year follow-up

References

ASHRAE, 2005. *ASHRAE Guideline 0-2005. The Commissioning Process*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA.

"*Understanding Drainage Planes*" by Lstiburek, J. *ASHRAE Journal*, 2006.

"*Understanding Vapor Barriers*" by Lstiburek, J. *ASHRAE Journal*, 2004.