# Balancing Your Building Enclosure: The Building Enclosure Commissioning Scope that Matters

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## ABSTRACT

Building Enclosure Commissioning (BECx) is a buzzword within the construction industry that does not have a universally understood and accepted definition. As a result, it is implemented in many different ways with various scopes of work. BECx is discussed in California Title 24, required in LEED v4, and mandated by many municipalities and states. But each of these different industry documents and municipality and state requirements have different definitions and requirements for BECx and it is rare to find a document that references the comprehensive industry standard – ASTM E2813. As a result, BECx is inconsistently performed across the industry and may not always be adding its full potential of value to a project. High-performance buildings are realized, in part, through the commissioning process. Since the building enclosure and the mechanical systems work in tandem to provide energy efficiency, durability, and occupant comfort, similar levels of oversight must be provided to each throughout the design and construction phases so they are equally commissioned and balanced. However, enclosure design and construction is different from the mechanical system, so the approach to BECx is necessarily different. This paper will provide guidance on establishing an efficient BECx process that provides value to projects and meets the requirements of various industry documents, including LEED. We will examine the appropriate time to begin the BECx process and engage the design team, necessary qualifications for a BECx authority, and unique field testing required.

## INTRODUCTION

Building enclosure commissioning (BECx) is a process to help verify that a building enclosure is designed and constructed to meet the owner's objectives. BECx has existed as a concept for many years but it has not been consistently well defined, understood, or utilized across the industry. New building performance standards, such as LEEDv4 and California Title 24, discuss the building-enclosure-commissioning process, but each standard has a variation of the definition and the process that is required. As a result, BECx is inconsistently performed across the industry and may not always be adding its full potential of value to a project. If implemented properly, the building-enclosure-commissioning process, can be very valuable: it improves quality, controls risk, and reduces costly changes and delays during construction.

#### DEFINING BUILDING ENCLOSURE COMMISSIONING

Commissioning (Cx), as a whole, is a process that is intended to help the design and construction teams deliver a building that meets the owner's goal and expectations for both quality and performance. The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) formally began the development of the commissioning process in 1982 and published the original commissioning guideline in 1989 followed by an updated

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version in 1996. This document was known as Guideline 1 ("HVAC&R Technical Requirements for the Commissioning Process") and was meant to document best practices to provide and operate facilities that performed according to the Owner's Project Requirements. Guideline 1 focused on the design and installation of HVAC and other mechanical equipment to achieve desired building performance. Through the 1990s and the early 2000s, the industry realized that a similar commissioning process could be applied to other building systems, such as the building's enclosure. At this time, ASHRAE teamed with National Institute of Building Sciences (NIBS) and they developed Guideline 0-2005 with the purpose of defining the general commissioning process regardless of the specific building system. Currently, ASHRAE Guideline 0 (The Commissioning Process) defines the general commissioning process as, "a quality-focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements." Although, this definition addresses the general sentiment and intent of commissioning, it is not specific to the building enclosure. Following this, in 2006 NIBS developed their Guideline 3 to specifically define the building-enclosure-commissioning process. Currently, NIBS Guideline 3 (The Building Enclosure Commissioning Process) defines BECx as, "the process by which the design and constructed performance of building-enclosure materials, components, assemblies, and systems are validated to meet defined objectives and requirements of the project, as established by the Owner." NIBS Guideline 3 includes a significant amount of guidance and examples related to building-enclosure commissioning but is long and can be a daunting resource for planning and executing enclosure commissioning work. In 2008, ASHRAE Developed Standard 202 ("Commissioning Process for Buildings and Systems") which presents the minimum requirements for the Commissioning Process without focusing upon specific building types, systems or assemblies, or on specific project sizes and in 2012 ASTM International (ASTM) first published ASTM E2813 - Standard Practice for Building Enclosure Commissioning. The following summarizes the general evolution of commissioning standards to the present industry standard for building enclosure commissioning.

- 1. 1982 ASHRAE Committee begins development of the commissioning process guideline
- 2. 1989 ASHRAE publishes Guideline 1 "HVAC&R Technical Requirements for the Commissioning Process"
- 3. 2005 ASHRAE teams with NIBS and publishes Guideline 0-2005 "The Commissioning Process"
- 4. 2006 NIBS publishes Guideline 3-2006 "The Building Enclosure Commissioning Process"
- 5. 2008 ASHRAE publishes Standard 202 "Commissioning Process for Buildings and Systems"
- 6. 2012 ASTM publishes ASTM E2813 Standard Practice for Building Enclosure Commissioning

# ASTM E2813-12e1

The industry standard specification for BECx is ASTM E2813 – Standard Practice for Building Enclosure Commissioning. ASTM E2813 is an attempt to pull together the disparate guidelines of ASHRAE Guideline 0 (The Commissioning Process), NIBS Guideline 3 (Exterior Enclosure Technical Requirements for The Commissioning Process), and ASHRAE Standard 202 (The Commissioning Process for Buildings and Systems) in a comprehensive but concise document. ASTM E2813 provides an industry accepted definition that Building Enclosure Commissioning as, "Building Enclosure Commissioning (BECx) is a process that begins with the establishment of the Owner's Project Requirements (OPR) and endeavors to ensure that the exterior enclosure and those elements intended to provide environmental separation within a building or structure meet or exceed the expectations of the Owner as defined in the OPR." ASTM E2813 consolidates the information from the other guidelines to develop a consensus within the industry on how enclosure commissioning should be performed.

ASTM E2813 defines two levels of BECx: fundamental and advanced, which differ based on when the BECx process is required to start, the number of technical design reviews that are performed, and the performance testing that is required. Both levels of BECx utilize a full commissioning process, including the development and review of the

BOD and OPR, identification of the BECx scope and budget, development of a BECx Plan, design phase design review(s), functional performance testing, documentation and training, and commissioning report. To comply with the fundamental BECx requirement, the BECxA must be engaged during the DD phase and is only required to perform one design review, while they must be engaged during the SD phase and perform three design reviews for the enhanced requirement. The standard provides a detailed breakdown of specific tasks and tests associated with each phase of the commissioning process as it applies specifically to building enclosures. For this reason, it is the most reliable and useful guide and reference for planning a BECx endeavor and is considered the industry standard due to its acceptance by the consensus organization.

## LEED v4

The U.S. Green Building Council (USGBC) LEEDv4 (Building Design and Construction) includes rating points for building enclosure commissioning. LEED v4 includes references to the ASHRAE Guideline 0-2005 and ASHRAE Guideline 1.1-2007 for the HVAC&R systems, and references NIBS Guideline 3-2012 for the exterior enclosure. LEED v4, like ASTM E2813-12e1, also defines two levels of BECx as fundamental and advanced. Previous versions of LEED included optional enclosure commissioning rating points, but did not include an enclosure commissioning prerequisite for certification. The fundamental commissioning level of LEED v4 is now a prerequisite, but only requires the BECxA to provide guidance on the development of the OPR and the BOD, as well as review of the OPR, the BOD, and the project design. The optional, enhanced commissioning level of LEED v4 lists the following additional requirements for the BECxA:

- 1. Review contractor submittals.
- 2. Verify inclusion of systems manual requirements in construction documents.
- 3. Verify inclusion of operator and occupant training requirements in construction documents.
- 4. Verify systems manual updates and delivery.
- 5. Verify operator and occupant training delivery and effectiveness.
- 6. Verify seasonal testing.
- 7. Review building operations ten months after substantial completion.
- 8. Develop an ongoing commissioning plan.

Note that LEED v4 does not include a reference to the industry standard specification for BECx, ASTM E2813. A number of these LEED requirements, such as "verify seasonal testing" and items related to operator training for example, are not particularly relevant or well-defined as they relate to building enclosures specifically. As such, many struggle with selecting a valuable and effective scope for the building-enclosure-commissioning work that meets LEED's requirements. Using ASTM E2831e1 as a basis for BECx scope when a LEED v4 certification is required is more practical and beneficial than using the BECx scope that is defined in LEED v4 and will be sufficient to achieve LEED rating points.

# **California Title 24**

Some states, such as California, include commissioning requirements as a part of their building code. The 2016 California Energy Code Title 24, Part 6 (California Building Standards Commission) requires commissioning, to some extent, on all non-residential projects. This code does not reference any of the Cx or BECx guidelines or standards discussed above and instead provides its own definitions and requirements. Title 24 requires all non-residential buildings with a conditioned space of 10,000 sq ft or more to utilize the full commissioning process that they define, including owner's or owner representative's project requirements; basis of design; design phase design review; commissioning measures shown in the construction documents; commissioning plan; functional performance testing; documentation and training; and commissioning report. All non-residential buildings with a conditioned space of less than

10,000 sq ft are only required to utilize the defined design review requirements. Title 24 does not specifically identify between Cx and BECx, however, it does specifically indicate BECx processes that are to be included, such as the enclosure performance expectations are to be included in the OPR, and the building enclosure components are to be included in BOD.

## LEVELS OF BECX

While ASTM E2831 provides a good guideline for selecting the appropriate commissioning scope, it is not typically a requirement for any specific project to follow the ASTM-prescribed scope. In addition, the commissioning requirements for each project are unique, and the Owner, with the help of the commissioning agent and the project team, must decide what parts of the process, what deliverables, what tests, etc. are applicable and appropriate for the project. This decision is largely driven by the level of quality control that the owner wants, the level of risk the owner is willing to accept, the available budget for commissioning activities, and by the requirements that are identified in owner-selected standards and certification programs, if any. There are varying levels of BECx requirements identified in ASTM E2831, LEED v4, and California Title 24 are illustrated in Table 1.

Tasks	ASTM E2831		LEED v4		California Title 24, Part 6	
	Fundamental	Enhanced	Fundamental	Enhanced	<10,000 sq ft	>10,000 sq ft
Third Party	Y	Y	Ν	Ν	Ν	Ν
Time of Engagement	DD Phase	SD Phase	DD Phase	DD Phase	SD Phase	SD Phase
Review / Assist with OPR	Х	Х	Х	Х		Х
Assist with BOD	Х	Х	Х	Х		Х
Prepare Cx / BECx Plan	Х	Х		Х		Х
Perform Design Reviews	Х	XXX	Х	Х	Х	Х
Pre- Construction	Х	Х				
Construction	Х	Х				
Functional Performance Testing	Х	Х		Х		Х
Occupancy / Operations	Х	X		X		Х

Table 1. Levels of BECx

This table generally summarizes the documents discussed above and does not include the myriad of municipalities and states that have commissioning requirements that differ. However, this table clearly shows that what is required in BECx varies between standards and certifications and that not all of these standards/certifications are coordinated with one another. For example, LEED v4 and ASTM E2831 both use the same "fundamental" and "enhanced" terms; however, LEED v4 does not reference ASTM E2813 and the fundamental/enhanced levels do not imply the same level of work. Below, we discuss the critical and impactful scope items and processes in BECx based on our experience on numerous commissioning projects.

#### THE BUILDING ENCLOSURE COMMISSIONING PROCESS

The industry definitions of Cx and BECx each recognize that they are processes versus a series of isolated and unrelated activities. Commissioning is intended to be an ongoing and continuous review and verification to confirm that the owner's project requirements are properly implemented and accounted for throughout the entire design and construction cycle. Unfortunately, not all of the commissioning documents are clear about this continuity of BECx reviews during the building process. Some of the most critical and valuable actives in each of the phases specific to building enclosures are discussed below, including how they relate and depend on one another.

## **Pre-Design**

The general project information and requirements are collected during this preparatory phase. Beginning the BECx process during the pre-design phase sets the foundation for it to be effective. The initial design assumptions and inclusions made at this time can impact the schedule and budget for the project and verifying their appropriateness will help to avoid costly changes in the future.

**Owner's Project Requirements (OPR).** The BECx process should start with a clear definition of the owner's project requirements (OPR). The OPR is a written document that outlines the owner's goals for the building enclosure, with particular attention to energy, environment, safety, security, durability, sustainability, and operation. The written OPR can take many forms, such as a statement of objectives or a table of requirements. The preliminary OPR developed during the Pre-Design phase establishes preliminary criteria that inform the development of the Basis of Design (BOD) and the Contract Documents (CDs). The OPR is subject to revisions during the Design and Pre-Construction phases of the BECx process. At a minimum, the OPR should establish the preliminary intent of the design indicating interior and exterior temperature, humidity, and pressurization conditions, desired service life and construction type, and energy use and sustainability requirements.

Developing a written OPR allows the Project Team to have a clearly defined understanding of the project's enclosure requirements and the Owner's goals. The BECX Authority (BECxA) can guide the discussion about the OPR for the enclosure and help define performance objectives. Although the OPR is subject to revisions during the Design and Pre-Construction phases of the BECx process, conducting a thorough discussion of enclosure goals and requirements in the pre-design phase, early in the overall process will improve the future alignment of the design with the owner's expectations. Once the OPR is clearly defined, the entire project team has a basis against which to make decisions and evaluate the building-enclosure design.

**BECx Plan.** During the pre-design phase or the early design stage, the BECx authority can prepare a written commissioning plan for the project. This plan includes an overview of the commissioning process, defines the roles and responsibilities of the various project team members, outlines the various planned commissioning activities, and documents the expectations for communication during the commissioning process. Although, the written plan may be revised several times during the project as requirements evolve, it is a valuable tool for keeping the project on track. Since the project team may not be familiar with the enclosure-commissioning process, reviewing and discussing the plan is typically an effective way of aligning the project team on the importance and expectations of the process. Keeping the plan simple, using tables and summaries to illustrate work-flow, responsibilities, testing requirements and restrictions, etc. make the BECx plan a more effective and useful tool for the project team.

#### Design

**Basis of Design Review.** Once the design team starts putting pen to paper, it is important that the BECxA periodically review the design team's work to verify that the basis of design (BOD) aligns with the established OPR.

The BOD can be a written narrative the describes the building enclosure systems that the design team intends to implement of the project. The enclosure systems selected for the project must meet the important criteria established by the owner. The BECxA is responsible for reporting BOD items that are inconsistent with the OPR to the owner, explaining the advantages and disadvantages of different approaches, so that the owner can decide to either modify the project requirements to accept the design change, or ask for adjustments in the basis of design.

**Design Documents.** The BECxA's should review the building-enclosure-design documents to help verify that the details and selected materials align with the agreed-upon OPR and BOD and that the performance tests and criteria are properly integrated into the project specifications. It is difficult, and sometimes impossible, to make major changes to a design once adjacent systems have been developed, construction pricing is under way, and aesthetic reviews have been completed, particularly with today's ultra-fast construction schedules.

Design reviews should be scheduled so that changes needed to align with the OPR can be implemented early in the design process. A review of the Design Documents by the building-enclosure-commissioning authority late in the schematic design or early in the design development phase can help identify fundamental issues that can still be resolved before detailing begins. A subsequent review in the early stages of the construction documents further allows the BECxA to comment on typical detailing of the enclosure systems and provide recommendations for system integration details. Yet a third review later in the construction documents phase can be helpful to make sure that all previous comments have been reviewed by the design team and incorporated where required to meet the intent of the OPR, and all necessary details and requirements have been provided. Since the BECxA is an agent of the owner, the owner is primary recipient of the BECx design review comments; however, practically speaking the BECx design review comments must be shared with, reviewed by, and responded to by the design team. It is important that the Owner be made aware of any decisions made by the design team that do not comply with their OPR. Many of the industry standards and guides are not explicit about the level and frequency of these reviews; however, the ASTM E2813 requirements for multiple periodic reviews during the design phase is the most effective and useful approach.

Design reviews typically include markups of the drawings and specifications and development of an issues log. The reviews will typically focus on integration of weather resistive barrier systems with fenestration, roofing, and belowgrade waterproofing systems; integration of the thermal, air, and vapor barriers between systems; unique details for integrating the building-envelope systems with one another; and evaluation of products under consideration for the project.

The issues log tracks all identified deviations of the design from the OPR. The envelope-commissioning process is not complete until each item in the issues log is resolved to the owner's satisfaction. It is important to note that the design team is not required to accept and incorporate the BECx comments, but to provide a response to the comments that satisfies the owner. The owner should work closely with the BECx authority during the design review process because it is the owner's responsibility to enforce the BECx authority's recommendations with the project design team or determine if changes to the OPR are acceptable. Some industry guides (such as LEED v4 and Title 24) allow the BECxA role to be filled by a member of the design team's firm that is not working on the project. While the design team firm member may have an advantage of being very familiar with the project and the design team's general approach and strategies, it is more beneficial to the project team and the Owner, if the BECx is an independent third party that can comfortably point out potential issues and make contrary recommendations because they have a different perspective than the design team.

**Performance Assessment and Testing Requirements.** During the design phase, the BECxA also helps the owner and project team develop appropriate performance assessment and testing requirements for the various enclosure systems. Performance assessment and testing typically includes pre-construction laboratory mockups, field constructed

off- and on-structure mockups, field testing at milestone intervals, and post-occupancy evaluation. The performance metrics relate directly to the established OPR. ASTM E2813 includes a nearly exhaustive list of lab, mock-up, and insitu performance testing options, some recommended and some required to fulfill ASTM guidelines. LEED v4 does not provide any specific requirements for performance testing. The Building Team should determine which tests will be performed and their required test values or performance measures, using ASTM E2831 as a guide. The BECxA can either prepare an enclosure-commissioning specification that includes all of these performance metrics, or confirm that the metrics have been integrated into other design documents.

Many think that performance testing of the building enclosure constitutes the major function of the BECx process. While field-performance testing is an important and significant part of the BECx process, the performance testing must be planned and assessed during the design phase for several reasons. The performance tests should be tailored to assess and confirm the performance characterizes of the enclosure that are most important to the owner. The enclosure design details should be prepared with these performance characteristics and tests in mind. Without this consideration, testing at late stages in the construction could result in failures that are very complicated and costly to rectify. In addition, performance testing can be expensive and time-consuming. If the testing is not thoughtfully developed during the design phase, it may not be properly included in the contractor's cost and schedule, making meaningful testing challenging.

## **Pre-Construction**

**Pre-Construction Bid Support.** During the pre-construction phase of the project, the BECxA can serve as a second reviewer for requests for information, addenda, and bids related to the building enclosure. Similar to the design phase, these reviews focus on confirming that items related to the building enclosure comply with the established OPR. Items that do not align with the OPR must be brought to the owner's attention for resolution with the Building Team. If few changes or questions arise during the bid phase, the BECxA's role in this work can be relatively limited.

**Pre-Construction Meeting**. In our experience, it is valuable for the BECxA to attend and participate in pre-construction or preinstallation meetings for the various building-enclosure trades. At these meetings, the BECxA can review and clarify the required performance testing and other quality control/quality assurance tasks to be performed. The BECxA should also review the general contractor's construction schedule to help verify that the enclosure-commissioning tasks are identified and properly accounted for in the construction schedule. This gives the BECxA the opportunity to review and clarify the required performance testing and quality control/quality assurance tasks face to face with the skilled trades who will be doing the actual work.

#### Construction

**Submittal Reviews.** BECxA can act as a second reviewer for building-enclosure submittals and shop drawings, and bring items that don't align with the OPR to the owner's attention for resolution with the design and construction teams. Identifying items in the submittals and shop drawings that do not align with the OPR and design can avoid costly and frustrating problems down the line. At this point in the project, the design team and BECx should be aligned on the final construction documents, and all design items should be resolved to the satisfaction of the owner. When that is the case, it is not critical for the BECx to review all of the submittals. Product and material submittals that comply with the contract documents should not require secondary review. BECx review can be limited to include only product and material submittals that deviate from the construction documents to help verify that they are equitable substitutes that comply with the OPR and design intent. The BECx can be most useful as a secondary reviewer of shop drawing for the various enclosure systems. Since the shop drawings will include critical performance details and transitions, the BECx can provide value insight and review of these documents, including helping verify that adjacent

systems are integrated appropriately.

**Site Visits.** The BECxA should perform periodic site visits as the building enclosure is constructed. During these visits, the BECxA should review the installed work to verify that the construction meets the intent of the contract documents, and therefore, the intent of the OPR. The number and frequency of site visits can vary depending on the size of the project, the complexity of the enclosure design, and the construction schedule. Including multiple visits for review and consultation on each of the enclosure systems, as they are installed, is critical. If only a limited number of site visits can be accommodated, it is most important to schedule them during the early stages of each enclosure-system installation so that any issues can be addressed before the work nears completion.

Similar to the design phase, the BECxA should keep a construction issues log for items that require further attention or adjustment to comply with the contract documents. The construction issues log will help the owner understand the items that need to be addressed and resolved. The construction issues log also simplifies later development and resolution of an enclosure-related punch list, since non-conforming issues are continuously tracked. It is important that the items on this enclose-related differences list are addressed soon after they are indicated because, unlike many aspects of construction, these items are often quickly covered up, such as when the exterior wall cladding is installed over the weather resistive barrier. As noted above, the BECxA does not have authority to change the design or direct construction work. It is up to the owner to discuss such concerns with the authority and promptly relay required changes to the project design and construction teams.

**Performance Testing.** The BECxA should witness the performance testing required in the contract documents. Whenever possible, it is good practice to require submittal of performance test plans from the testing agency that the BECx can review prior to commencement of the testing. The test plans should outline all of the test procedures and the anticipated passing criteria as indicated in the contract documents. This will help avoid misunderstanding during the testing that prolong or delay the proper execution of the tests. The BECxA should verify that the proper performance tests have been performed, the test procedures were correctly followed, and that the test results indicate conformance with the OPR. The owner may elect to have the BECxA conduct performance testing itself (assuming the individual has the appropriate qualifications) to further assure proper testing methods.

Requiring off-structure mockup testing of the component building-enclosure systems can be effective in establishing quality standards and verifying that the designed systems are capable of meeting the required performance metrics. Off-structure mockups can be completed well in advance of building construction, allowing time to integrate any changes that may be needed for the tested system to meet the established metrics. On-structure mockups are less expensive and less labor-intensive than off-structure mockups; they can also be effective, provided that necessary changes can still be incorporated in the manufacturing/fabrication process or during erection. On-structure mockups completed too late in the process can result in changes that cannot easily be accommodated without significant implications to schedule and budget, so they are sometimes not as viable as off-structure mockups.

After mockup testing is complete and installation begins, the initial installation should be tested. This will help confirm that the materials and systems delivered to the site and their installation on the building match the quality and performance of the mockup. Testing the initial installation gives you a chance to make needed changes or adjustments before the bulk of the construction is completed. Periodic testing thereafter can serve to verify that the installation quality remains consistent throughout the life of the project. All testing must be coordinated with the construction schedule to make sure that necessary testing is not abandoned in an effort to maintain completion deadlines.

## **Occupancy and Operations**

We have found that, unlike mechanical systems commissioning, there is limited benefit to participation in the

occupancy and operations phase of most projects by the BECx. Most critical building-enclosure systems and components are concealed within the assemblies, allowing little opportunity for testing and inspection once construction is complete. This is, in part, why it is most critical to have the BECx involved during the design and early construction phases of the project. The BECx can also visit the site some months after construction is complete and before the end of any initial warranty periods. The BECx authority can discuss performance of the building enclosure with the facilities personnel and make general observations that could indicated improper performance or maintenance needs. A BECxA post-occupancy site visit is required by some standards and guides, such as LEEDv4.

## The Building Enclosure Commissioning Authority

The Building Enclosure Commissioning Authority (BECxA) will lead and coordinate the commissioning team to implement the enclosure portion of the commissioning process. The various industry guidelines indicate that the BECxA may be an independent third-party, part of the owner's in-house staff, or be an employee of the design team that is not actively involved with the project being commissioned. We recommend that the BECxA be an independent third-party reviewer that is not part of the design and construction team, although this is only required by ASTM E2813. This independence helps make sure that the BECxA is focused solely on verifying that the design and construction meet the OPR requirements and acts in the best interest of the owner. The BECxA must be very knowledgeable of the building enclosure systems to be used on the project so that they can provide thoughtful and technically accurate advice to the owner and oversight of the project team's enclosure design. The BECxA must also be proficient in building and material science, construction contracts and administration, and performance test methods and standards. To date, there is no national standard or certification process for evaluating and credentialing BECxAs. However, owners can evaluate the skill and appropriateness of a BECx by reviewing experience with the BECx process in general, and the building enclosure systems and performance tests to be used on the specific project. An experienced BECxA should be able to provide specific project and work-product examples relevant to the project.

#### CONCLUSION

The building-enclosure-commissioning process helps reassure the building owner that the design has been properly evaluated and implemented for the purpose of meeting the OPR; however, the BECx process must be implemented thoughtfully to be a reliable and effective way of assuring quality in the building enclosure, without becoming cumbersome and adversarial. The building-enclosure-commissioning process should not be viewed as a replacement for good design. To be most valuable, building-enclosure commissioning must be executed as a process from predesign through construction. One key to a successful BECx process is just that – ensuring that it is a process that is ongoing throughout the design and construction phases of a project. Implementing only isolated portions of the process, such as limited performance testing or construction checklists, will be ineffective, if the original OPR and basis for the design is not appropriate. Above, we discuss the scope items, to be taken as a whole that are most beneficial and valuable when planning and executing building-enclosure commissioning work. Even a project with a tight budget and/or schedule can benefit from a limited scope of BECx, provided that the tasks are selected to get the most benefit for the owner. The tasks most critical and valuable in the BECx process include

- 1. Pre-design consultation on the OPR and BOD. This can be limited to a review of the design team's narratives and/or participation in a meeting(s) to review and discuss these items. Dialogue with the owner is critical at this stage to help verify their requirements are clear and represented in the BOD.
- 2. Preparation of a simple BECx plan and/or a BECx specification. The plan can be a simple tabular summary of the expected commissioning tasks and the responsible parties for each of the tasks to help the team understand expectations. The BECx specification is helpful to provide a comprehensive summary of all the required construction-phase performance testing.
- 3. Review of the design team-prepared construction documents. Three reviews are most beneficial typically at (1)

100% schematic design or 50% design development, (2) 50% construction documents, and (3) 90% construction documents.

- 4. Attendance at a pre-construction meeting(s) with the relevant building enclosure sub-contractors. This meeting helps make sure that the construction team understands expectations for performance testing so that it can be integrated into the project schedule.
- 5. Secondary review of submittals and shop drawings. For efficiency, these reviews can be limited to submittals for materials that differ from what is included in the contract documents and shop drawings.
- 6. Site visits to review work in-progress. At a minimum, the BECx should visit the site early in the installation phases of each of the enclosure systems to help detect and correct issues as early as possible.
- 7. Review of functional performance test plans, witnessing of functional performance testing and/or review of performance test reports. It is not critical for the BECx to perform the testing themselves, but to help verify that the appropriate tests are performed correctly and the results comply with the OPR.

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