Building Envelope Commissioning: From Schematic Design to Successful Operation

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Abstract

Standard Practice for Building Envelope Commissioning (BECx), ASTM E2813-12, was developed to ensure the building enclosure and the elements separating exterior and interior environments of a structure meet or exceed owners’ project requirements, building codes, and industry standards. The practice is gaining greater recognition, primarily in new construction. However, correct implementation of the practice tends to focus mainly on the construction phase of the work. Successful BECx is dependent upon the commissioning agent’s (BECxA’s) involvement, starting in the predesign phase and continuing through design, construction, occupancy, and completion in the operations phase. BECx must maintain a continued focus on quality of the design, as well as construction and operation of the final product.

Speakers

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INTRODUCTION

The building systems commissioning process, originally developed in Canada and the U.S. in the mid to late 1980s, was intended to provide mechanical, electrical, and plumbing (MEP) design engineers and building owners assurance that the primary heating, ventilation, and air conditioning (HVAC) equipment functioned as intended through a series of five commissioning levels: witnessed factory testing, site acceptance inspection, prefunctional testing and startup, functional performance testing, and, finally, integrated systems testing.

By the early part of this millennium, the commissioning protocol expanded to include a larger group of design professionals and the construction team, evolving to include a quality assurance and quality control process. The primary intent of the process was to confirm performance of all operational components within a project, ranging from smaller instruments with individual functions, to complex, integrated systems with modules and subsystems.

A natural progression of the commissioning protocol was the extension of the concept to the building enclosure. The combination of the mechanical systems and the enclosure elements, from design to in-service evaluation, was an ideal pairing focusing on energy efficiency, overall building performance, and durability of the enclosure elements. The recent implementation by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) of ASHRAE 90.11 and the adoption of the International Energy Code in many states underscores the interrelation of the HVAC system, building envelope performance, and energy conservation.

This discussion focuses on the need for a single, well-defined, fully integrated design/construction/quality process, or building enclosure commissioning, and the inherent challenges with the practical application of a process originally intended to test functioning equipment, when employed to confirm performance of many integrated elements, both active and passive.

HISTORY

The implementation of the commissioning (Cx) concept first began in Canada in 1977 for delivery of public works projects. In 1981, Disney World adopted commissioning in the construction and startup of Epcot Center. In 1984, the University of Wisconsin at Madison began to offer commissioning courses. That same year, ASHRAE formed the HVAC Cx Guideline Committee. In 1988, the Texas LoanStar Program introduced monitoring and existing building commissioning to public sector building construction (Figure 1).

Both ASHRAE and the Bonneville Power Administration published the first commissioning guidelines in 1989. Between 1989 and 1996, numerous public and private entities, as well as industry associations and committees, launched commissioning programs and published commissioning documents. In 2004, the National Institute of Building Sciences (NIBS) formed a committee to document best practices to achieve exterior enclosure systems that performed according to and met the owner’s project requirements. This resulted in the NIBS Guideline 3-2006, “Exterior Enclosure Technical Requirements for the Cx Process.” ASHRAE replaced its 1996 Guideline with ASHRAE Guideline 1-200X, “HVAC&R Technical Requirements for the...

Figure 1 – The BECx objective is true integration of the project requirements, collaboratively with the project team, encouraging a move away from the checklist system.
Commissioning Process.” The commissioning process requirements were placed into the ASHRAE Guideline 0-2005 with the specific HVAC&R elements supporting the more general commissioning guideline. This publication was the result of a joint program between ASHRAE and NIBS to promote a uniform guideline involving a range of disciplines and buildings systems and introduced a wider range of design disciplines and building systems, but did not provide clarity as to the components or systems included in the process.

ASHRAE followed in 2013 with a standard in 2012, establishing a practice for the commissioning of a building as a standard in 2009, and was eventually published around 2009,

ASTM E-2813 began its development around 2009, and was eventually published as a standard in 2012, establishing a practice for the commissioning of a building enclosure, starting from conceptual design and ending one year after building completion, or at the time building operations are transferred to the property manager. ASHRAE followed in 2013 with ASHRAE Standard 202.

This 26-year process, developed by both public and private agencies in two countries, created similar, yet not identical, documents promoting the same general principles with differing methods of execution. In many areas, the paths of execution were not fully defined, creating options for the user to reach the intended goals.

THE PROCESS: FROM SINGLE SYSTEM TO WHOLE BUILDING

The confirmation of performance of the building enclosure is more complex than the original five levels of commissioning developed in the early ASHRAE documents used to confirm performance of operational components. Standards and protocols referencing numerous testing criteria have been developed by industry associations and adopted by both public and private entities over the past two decades, creating a range of approaches to commissioning.

What has clearly been learned over that period of development is: The commissioning process requires collaboration, starting with conceptual design, and should remain in place through monitoring and testing well into the first year of building service. The process requires the engineering and architectural disciplines to communicate with one another as the design takes shape, merging ideas and concepts in the early stages with the primary goal that of meeting the owner’s project requirements. The commissioning agent plays a critical management role, coordinating the numerous disciplines to focus on issues in the early stages of design and to avoid redesign in the later design and construction phases.

The initial process of building enclosure commissioning, known as BECx, begins with the development of the owner’s project requirements (OPR) in the predesign phase. The owner’s building criteria should be fully incorporated into the OPR with consideration of energy performance, the impacts of the local environment, safety and security considerations, durability, sustainability, and building operations. The goal of the OPR is to clearly define the specific criteria of the owner for the building use, with a decisive plan from project inception, to provide an energy-efficient, fully functioning enclosure that meets the owner’s stated needs.

The OPR should be developed and generally defined during the same timeframe as “programming”: the exercise used by the architect during early schematic design to determine building size and general layout. During the design development phase, the architectural exterior design concept is married with the owner’s preferences and enclosure elements established in the OPR through a materials matrix. This is a coordination tool that lists all envelope systems with materials. The matrix is a living document that will likely go through numerous iterations throughout the conceptual and design development phases. The end goal is to turn over to the owner, at the date of sub-

Example: Critical Fact-Finding During OPR Development

The future service life of the building must be considered at inception. As an example, if the owner intends to build a structure meant to temporarily house equipment/operations for a ten-year period, after which a new structure in a different location is planned for housing the same machinery and operations, can the enclosure be constructed to be viable even after equipment removal for an alternate use, or should it be designed with material choices for a short life cycle?

The selection of materials and assemblies as a part of the materials matrix will help establish the OPR and basis of design in the very early stages of the project.

The design of the enclosure will be somewhat dependent on the operations and equipment housed within. Interior operations will have a direct impact on the enclosure. Operations may create high levels of humidity, multiple environments within the same structure, excessive heat, and large percentages of glazing creating radiant gain, to name only a few. The enclosure design must start with a clear understanding of the operations and the impact they may have on the enclosure and the operating mechanical systems. Moreover, the as-built drawings must detail all the elements, so any future intended use of the structure has a starting point for any needed redesign. As an example, data centers may have differing temperature and humidity requirements within the same structure. The designs for generator and battery rooms will be substantially different than the data hall or offices. All must work in concert and may require a component of design be used in future expansion of one or more of the subsystems in the building. The materials matrix development should take into consideration the intended service life of the structure. This may include the initial service life plus some future service life for future building use.

Again, using a data center as an example, initial service life as a data center is 15 years. Should the roof design contemplate 15 years of service or an extended period to incorporate some future use? This should be one of the considerations in the OPR, a direction that can only be determined by an owner. The agency of record (AOR) and the design and construction teams can provide input such as cost considerations to assist in the design process.

As a further example, if the owner has expectations of expanding the facility during the early service life, building enclosure design should consider material availability at the time of the anticipated expansion. Designs should also incorporate the installation of elements that will accommodate the potential future expansions without causing damage to originally installed components.
stantial completion, a building that delivers in both form and function and meets the criteria of the OPR, with optimal combined enclosure and mechanical performance.

BECx brings to the design and construction process a quality focused concept replacing the more traditional and commonly used checklist system typically used during both design development and review of completed construction elements—a process that currently dominates commercial construction. The BECx objective is the true integration of the project requirements, defined by the OPR into each phase of design and construction, to completion and early implementation (Figure 2).

A key element of BECx is the testing of finished products to confirm performance and effective integration. The process continues in the design phase with the design and integration of the enclosure elements, through early modeling of the exterior wall systems, using software programs such as WUF1 to provide careful evaluation of the various materials that form the enclosure. Detailing of the enclosure systems, generated with the assistance of building envelope consultants (either through a separate set of waterproofing or building envelope documents or fully integrated into the architectural detailing), is then incorporated into the architectural construction documents. The finished product is eventually field-tested using established test methods. The 2012 ASTM standard references no less than 90 published test standards and protocols, listed both in reference documents and in Table A2.1. This extensive list is intended to guide the selection of relevant tests for the commissioning process through incorporation into the owner’s project requirements and, eventually, the project specifications.

Critical to the process during the construction phase is contractor training and full participation in a thoroughly integrated quality assurance/quality control (QA/QC) program extending to the subtrade level, and verification of system performance through document review, field oversight by self-monitoring and BECx auditing of the installation, and finally, testing of the enclosure components and systems to confirm compliance with overall design. BECx success requires early commitment by every member of the design and construction teams, all of whom must understand the OPR, the design documents, and the BECx process. Establishing these concepts at inception of design and within the preconstruction process eliminates the “police-action” process of random findings of noncompliance and directives to repair only those items that have been identified. This is where the BECx will provide one of the greatest values to the final product, creating multiple levels of oversight, starting with the contracting entity and extending to a comprehensive testing process of the final product.

PREDESIGN PHASE

(See sidebar example, page 118.) The BECx starts with a well-defined OPR that has been transmitted to all parties who will design and build the structure. While some owners are capable of OPR development, many others will need assistance to formulate the full document. The architect plays a pivotal role in the creation of both the programming and OPR documents and will likely require input and guidance from multiple disciplines, such as mechanical, electrical, civil, structural, acoustical, and building envelope consultants. Ideally, the BECx would participate in the development of the OPR.

The building envelope consultant will have expertise to develop and integrate the waterproofing design into the architectural elements of the enclosure. To create an optimal waterproofing design, the work must be coordinated with the mechanical aspects of the project and must be successfully tested under the commissioning process to prove performance. The commissioning agent (BECxA) must have familiarity with the over 90 test standards and protocols referenced in the ASTM commissioning document and the ability to either carry out the testing or collaborate with third-party entities capable of executing the specialized test standards.
The BECx A should be capable of making recommendations as to which tests are relevant to the project and suitable for the systems installed. To add to the challenges, standards and protocols may require modification to develop relevant data, depending on the type and configuration of the structure. (Figure 3).

The building envelope consultant will typically assist in the drafting of specifications for products incorporated into the materials matrix. Once identified, the components and systems will be evaluated and the test requirements formulated based on the specified general requirement for quality and BECx outlined in the Division One section of the specifications. Physical property and system testing requirements, typically forming a part of the submittal process, will be identified and incorporated into the individual project specifications. Additionally, the BECx A will outline the field-testing and provide guidance in defining the requirements for the installing contractor to support the testing in the specific building envelope specifications.

Alternatively, the owner and architect may independently incorporate the ASTM (or alternate practice) into the OPR and specifications; however, without the guidance and coordination of an experienced BECx A, the requirement to effectively identify and perform the 90-plus test standards referenced may be a daunting task. This could result in unnecessary and costly testing for the owner, as some of the referenced standards and protocols are redundant. For example, AAMA 501 and ASTM E1105 for window testing are both listed in the standard and could provide identical results if both are required under the BECx. Some of the testing may only be applicable in certain regions of the country or with specific types of envelope elements. The experience and expertise of the commissioning agent can play a vital role in the testing matrix and the eventual testing budget.

The ASTM standard states, in Annex 2:

Selection, interpretation, application, and use of each test standard included in [the standard] shall be specified at the sole discretion of the Architect of Record (AOR) in direct consultation with the BECx A during the design phase of the BECx process, subject to final review and approval by the owner. Specification and use of the individual test standards allowed under this practice will vary based upon the OPR and relative influence of the attributes listed [within] this practice.

The BECx A should possess the knowledge and experience to guide the owner and the design team through the process of incorporating BECx into the OPR and construction documents. The BECx A should assist with the distribution of the OPR to ensure it is transmitted to all the design professionals at the initiation of the project. The OPR must also be made a part of the plan of record (POR).

The BECx A should also participate in budget development for the building enclosure elements. A project budget should be incorporated into the OPR as early as possible to inform the owner of the costs associated with the OPR criteria. The building enclosure costs are typically evaluated by the owner in combination with other project financial demands and often result in requests for value engineering to balance the overall project budget. Higher-than-anticipated site improvements or permit revisions can reduce the overall budget allocated to the structure. An effective tool within the materials matrix can be developed, creating primary, secondary, and tertiary material options with graduating unit costs, all of which meet the established OPR criteria. The differences in each category may affect both cost and anticipated service life.

Once the preliminary documents have been developed into a schematic design, the architect will distribute them to the full design and BECx teams and review the documents and budgets with the owner. The BECx A will be tasked to review the schematic design and compare the enclosure elements with the OPR, materials matrix, and the POR. Coordination meetings should take place with all disciplines that have contributed to the mechanical and enclosure designs. The primary goal is to identify and work out conflicts within the early stage of design. Material and system suppliers should be consulted when modified assemblies have no system performance testing to meet code and insurance requirements. Material suppliers and contractor review of the assemblies may also bring to light constructability issues not picked up in the initial schematic design.

DESIGN PHASE

Once the POR is established and the schematic design is issued by the architect, the BECx A takes on the role of a messenger, cycling information, comments, and design proposals among entities within the design team to further enhance the design and coordinate the formulation of the written and graphic design documents. The BECx A assists the architect by keeping the design development in line with the OPR and the materials matrix. This may include a role in red lining documents for consideration by the design team.

Through a generally cyclic flow of information, the BECx A must continue to coordinate—and in some cases, participate in—the integration of the building enclosure design. Specifications will likely require updating and revision as the material matrix is updated and enclosure requirements are changed.

Structural, architectural and mechanical design development will require coordination, including new and revised detailing with additional specification revisions. Issues of constructability should be reviewed for comment by the BECx A in collaboration with the construction group and the design team. Unique interior environments, such as indoor swimming pools, refrigeration/freezer warehouses, and data halls will require specialty enclosure designs with a higher level of collaboration and coordination than a typical office or mixed-use project.

As the designs evolve through design development and construction documents, the BECx A should assist in the development of specific language forming the QA/QC requirements. The anticipated BECx testing should also be incorporated into the project schedule to assist the contractor and owner in site coordination and scheduling. Specifications should also establish a process for finalizing one subtrade’s installations and turnover of the completed enclosure element to the general contractor for protection from damage by subsequent trades who may ultimately use the completed work as a work platform.

Education of the entire project team by the BECx A during the design phase is a difficult yet necessary step. The tendency is for a contractor to focus only on those parts of the project where there is direct responsibility. Until the BECx concept is fully integrated into the day-to-day construction standard, there will be a continual need for
education and a push for the development of standardized templates that can be used on all projects by all subtrades.

Much of the incorporation of the BECx will be in the written word, not in the design drawings. The integration of the OPR into the project specifications must be a part of the regular design coordination. In many ways, this concept and practice is still a work in progress for the industry. There is no written process for the OPR development or its integration into the design documents. The role and level of involvement of the BECx can change from project to project, depending on owner involvement and contracted scope with the architect. Building envelope commissioning specifications have been developed and incorporated into Division One sections; however, the integration of the concept into the material and installation specification sections, and the implementation through preconstruction conferences and the development of internal monitoring and auditing, are yet to be fully incorporated and developed in a standardized manner.

Currently there is no single process developed and adopted by the industry. The BECx must formulate the process for each individual project, by working with specification writers and other members of the design team to fully integrate and communicate the concept through the written word. The development and adoption of templates and forms that can be appended to or incorporated in specifications would streamline the process. With some coordination between institutes and associations, standards could be agreed upon and templates published that all contractors could adopt. The practice could be commonplace in the construction phase of the work. Classes to better educate quality assurance managers could minimize on-site learning curves that are commonplace today.

Additionally, the OPR for QA and QC should be fully defined within the specification documents and must apply to all enclosure elements installed. The QA/QC requirements should include a detailed program for the general contractor for incorporation into their project manual for execution by the entire construction team. Adoption of the QA/QC program should be clearly defined as a contractual obligation for the general contractor and must be incorporated into the contracts of all enclosure trades. Templates for the QA managers with related reporting documents should be developed in a form consistent with the general contractor’s on-site software programs. The programs should create an audit trail, starting with substrate acceptance, and create a written acknowledgement by the installing contractor that the underlying materials are suitable and adequately installed for the installation of additional layers. This is a third-party review, since the underlying materials should have already gone through a similar QA/QC process.

The ASTM standard states, “The practice [of BECx] is not intended to warrant or otherwise guarantee the as-built or in-service durability, or both, and performance of enclosure materials, components, systems and assemblies.” The assurances and controls to ensure conformance to the project requirements and a delivered quality product are the responsibility of the general contractor and, to a larger degree, the installing subtrades, regardless of the number of third-party inspections or observations that take place during installations.

### PRECONSTRUCTION PHASE

After designs are issued for construction and documents are released for pricing, the preconstruction phase of BECx commences. ASTM E2813 outlines preconstruction activities, including:

1. Prebid conferences
2. Bidder requests for information, clarification, and development of bid addenda
3. Review and evaluation of bids, including any value-engineering suggestions from bidders
4. Updates to the owner plan of record and basis of design with approved modifications related to the bid phase

Attendance at prebid conferences affords the BECx the opportunity to ask specific questions related to both specified and proposed substituted products, referenced industry standards and practices, and the contractor’s approach to QA. The involvement reinforces the continued coordination among the architect, consultants, and BECx, and assists in the development of a unified, consistent approach.

Once bids are received, the BECx may assist in evaluation of the bids through analysis of the bidding contractor’s knowledge, from both the interview process and evaluation of the bid submissions. Budgets developed during the predesign phase can be compared to submitted bids. Additionally, any products submitted by the bidders for value-engineering purposes can be evaluated jointly with the architect to determine whether the OPR can be met through employing the proposed products.

### CONSTRUCTION PHASE

The construction phase vernacular typically identifies project, submittal review, preconstruction, and preinstallation meetings as a part of preconstruction. ASTM
E2813 incorporates these functions into the construction phase of the project. These are critical functions in the commissioning process, requiring collaboration and coordination by the design and construction teams. The BECxA must take a leading role in ensuring adherence to the OPR and the implementation of the QA/QC and field-testing programs. During the submittal reviews and preinstallation conferences, the stage is set for the incorporation of the program into the construction phase.

In addition to the parties identified above, the BECxA must coordinate and incorporate the activities of the third-party inspectors, manufacturers’ representatives, and building code and insurance representatives to complete the quality assurance and commissioning plans.

The contractor commitment discussed above is required for implementation of a QA/QC plan that defines the procedures to manage and control all trades and supplier activities so the completed project meets the goals of the contract documents. The QA/QC plan should include a clear definition of the roles and responsibilities of each entity and individual with a concise methodology of reporting, including timelines and deliverables. The program should define a proactive process that identifies deficiencies quickly and corrects them during the installation process, rather than a reactive system where outside inspection is used to assess quality after work is completed and repairs are carried out after the fact.

Historically, the exchange of information among owner, architect, BECxA, general contractor, and subcontractors has been a source of frustration. The process has been a paper trail that included photographs and handwritten notes, transcription, downloading and captioning of photographs, and ultimately, finalizing a single document for distribution. The effort to keep everyone up to date and on the same page has been challenging. With today’s software programs, cloud computing, and digital mobile media, the process has become streamlined and has improved how quickly communication from the field to the relevant parties takes place. Software has been developed for tablets and other mobile devices that allows photographs to be taken and captioned and issues to be logged at the time of observation. The software programs used in the field are able to generate a report to allow distribution within hours of observation (Figure 5).

The appointed quality assurance managers must develop a self-monitoring program to observe the work and initiate corrections during the course of the work. The completed daily report delivered to the general contractor, the BECxA, and the design team should affirm and document the daily install in compliance with the contract documents. The BECxA will audit the daily reports by review of photographs and compliance certifications in conjunction with field audits to verify authenticity of the reports and certifications. Auditing of the paper trail and spot field-authentication testing of installed elements, combined with field testing, will provide a positive affirmation of compliance rather than the “catching” of random deficiencies after the fact. The discovery of these conditions during the service period becomes costly for the owner and the construction team alike.

The preinstallation process should include a presubmittal review with the BECxA for each of the enclosure trades. This affords the opportunity of a “page-turn” of the project details and a materials review. The outline of the QA/QC process, generally defined in the Division One specifications during the design phase, should be reviewed by the QA manager for each trade designated. Suggested forms and templates can be distributed for adoption by the trades. General contractor reporting and deliverable requirements should be reviewed to streamline the process to avoid duplication or submission through multiple electronic systems. Any outstanding constructability issues should be raised by the trades for early consideration and, if needed, modification by the design group. The presubmittal review is designed to smooth the submittal process with a minimum of hang-ups. The design and commissioning teams are seen as collaborators within the process, working to assist in the administrative elements and reduce potential conflicts at the start of each trade’s work. The process also allows the trades to demonstrate their expertise in the field and provide input on materi-
als, material substitutions, and installation methodology at an opportune time. The process enhances pride in workmanship and a genuine feeling of inclusion in the process.

The submittal review should become an easier process after the presubmittal review. It can be reasonably expected the submittals will be complete and the QA/QC program be fully developed. The BECxA may wish to meet with the QA managers as a group to further streamline the process where the work of multiple subtrades interacts. This will assist the general contractor in coordination and scheduling of the work. It may also assist in the development of similar QA documents, since each subtrade is tasked with the development of its own program. Submittal logs should be established and updated, with access granted to the appropriate parties to reference documents as needed. The BECxA should have access to the submittal log, including any changes to the products or work that may be approved by the design team through substitutions or the request for information (RFI) process during the installation of the work.

The preconstruction and preinstallation meetings bring all parties involved with the installation together for a final review, and include the involvement of the manufacturer’s representatives and third-party inspection teams. In a typical construction process today, these meetings may be the first time the parties have met face to face, many times with incomplete submittals and no development of the QA/QC program. The preconstruction and preinstallation meetings can focus on the agreed-upon finished product and the upcoming mock-ups or benchmark installations.

The mock-up provides the opportunity to review the process of installation, as well as the finished product. It should be as realistic an application as possible to reflect actual installation conditions. The QA managers should have the opportunity to review the installation with the design team, third-party inspectors, the manufacturers’ representatives, and the BECxA, further developing the team approach to installation and approval of the finished product. The QA managers should write up the installations as if they were a day’s work, providing a dry run for the actual process. This can be the subject of a team review of the final product, as well as supporting the daily review to meet the QA/QC daily reporting requirements. The mock-up should remain in place, whether to be incorporated into the work or not, as a visual display of approved work.

Periodic or full-time observation of the work may be a component of the contract. There may be various reasons for the differences in observation, based on specific concerns of an owner, such as a problem roof on a prior project, to the practicality of full-time inspection for certain types of work, such as sealant joints and glazing. There may also be requirements for manufacturers to review and approve work from time to time to meet the requirements of the contract documents or warranty provisions. These must be coordinated with the general contractor, the BECxA, and the QA managers. The method of reporting these visits should be streamlined into the daily reporting functions to create consistency and confirm delivery to all of the intended parties.

It is not uncommon for the site observations of various parties to conflict. This may well be a result of differing focus at the time of inspection, rather than differing opinions about the observations. Fast and efficient delivery will afford the opportunity to correct these conflicts and create an accurate record with consistent recommendations for any remediation. It is common for manufacturers’ representatives to visit a site independently and report findings through a different avenue, well past the time of site observations. The conditions observed may have been addressed by the time the report is received by the appropriate parties, or the deficiencies observed could have been fully incorporated into the work, requiring complete removals to correct the observed conditions.

The audit process carried out by the BECxA is a relatively new concept implemented in conjunction with the daily reporting of the contractor or subcontractor QA manager. The preconstruction process educates the appointed QA manager about the project, materials, and method of installation. His or her job is to observe the work daily and document and report the events of the day, including the identification and repair of any nonconforming work. The goal at the end of the working day is to provide confirmation and certification of the conforming work. While the daily document may identify and discuss deficiencies and the methods of correction undertaken, the primary goal is to have certification of compliance and documentation of any issues that may require correction the following day to bring the installation into conformance. The BECxA audits these daily documents and develops a field audit program, likely in conjunction with third-party inspectors, if on-site, to confirm adherence with the project documents. The audit program reinforces confirmation of compliance and, in some cases, catches nonconforming issues that may have been missed or overlooked. The purpose of the audit is not to develop a police action, but to assist the QA manager with the process. If noncompliance issues are identified, the BECxA can work with the QA manager to strengthen the program in the early stages of the installation.

Another important tool in the process is submissions by the sub-trades of requests for information or clarifications to the project documents. The design team may use the BECxA to support responses or provide additional comments as they relate to the building enclosure. As noted, the BECxA should be copied on all such documents with a specific request for comment, if needed.

As aspects of the enclosure are completed, testing of the installed products will begin. It is common for the testing to begin at the completion of the work. An example of this is simulated wind uplift testing of a roof at the completion of the work or section of the roof. Early testing of the envelope components before completion of a section or elevation can identify problems early in the process. Testing can also be used to validate or displace concerns raised during the installation process. Early testing can speed the turnover of sections of the work to the general contractor and may shift the responsibilities for protection much earlier in the process. The responsibilities of protecting the work—both during construction and after completion and testing—should be fully discussed and agreed to prior to the commencement of work. Enclosure components, such as below-grade waterproofing and roofing, are regularly damaged by other trades, due to lack of a coordinated plan for protection.

The testing schedule must remain fluid and adjust as the construction schedule changes. The coordination of the testing should be a topic in the weekly meetings to keep all parties apprised of changes. In almost all cases, the installing contractor will have a role to play in the testing, over and above the reporting on QA. This may be
the preparation of surfaces, lifting of equipment, or repairing damage to tested areas, to name a few of the tasks. Weather conditions play a role in the coordination and completion of the testing.

The BECxA plays a coordinating role between the on-site installers and design team during the construction phase. There is also a direct role in the QA/QC audit and the completion of the confirmation testing. The BECxA must have the ability to communicate effectively with all parties, collecting and disseminating information in a timely manner. The BECxA takes on the role of the team manager in the initial phases, moving to an active player/manager as the auditing and testing phases are under way.

The process outlined removes the concept of a police action during and after the implementation of the work, substituting a more collaborative approach with positive verification of performance at the end of the work.

If the systems are operating as intended and integrated as contemplated in the design documents, the owner has a good chance of a building start-up with the HVAC and envelope elements working in concert, with little need for revisions or remediation within the start-up period.

OCCUPANCY AND OPERATIONS PHASE

As the project draws to a close, the documentation that formed the design, together with submittals and design changes, must be combined to create the historical record of the construction. In addition, the Operations and Maintenance Manual must be developed to provide facilities personnel with a clear roadmap to maintain the envelope components. The Operations and Maintenance Manual is more than a collection of the manufacturers’ published information. Entries should provide clear and complete direction for the care and maintenance of all the elements making up the envelope. Estimated service periods for paints, sealants, and stains should be provided. Intervals for adjustments of doors, windows, and paver platforms should be included. Regular inspection of the components should be suggested, with listings of qualified entities to carry out the work.

Copies of wall warranties should be included in the manual, with contact information for both the original installer and the warrantor. The contact procedures and maximum contact time for notice should be highlighted for ease of identification.

During the occupancy and operations phase, all envelope components should be visually inspected to confirm performance. Any accelerated surface deterioration should be brought to the attention of the contractor and the warrantor. A log of all issues should be maintained with a procedure to fully close out all issues identified. The maintenance staff should be involved with any contractor walk-through to develop some familiarity with each of the envelope components.

The “Issues Log” should be fully closed out at the completion of the occupancy and operations phase, with maintenance staff generally familiar with the systems and the documentation.

CONCLUSION

The concept of commissioning has been evolving over the past 26 years. Multiple groups have worked both independently and in collaboration to create a variety of documents for the industry to follow. The commissioning process for the building envelope is a clear advancement from the more common checklist and site observation concept that has been in place for the past 60 years. The practice established under ASTM E2813, combined with the commissioning procedures for the HVAC systems, provides—from conceptual design to building turnover—a practice to combine the talents of the multiple disciplines involved in design and construction, with a collaborative effort to positively confirm performance consistent with the design intent.

The practice, however, must be coordinated by, and in some cases executed by, a BECxA who understands the process from design conception to building turnover. The BECxA must understand his or her role during building envelope predesign and design phases, as a team co-manager with the architect, ensuring communications between various consultants and the architect take place to create an integrated enclosure that meets the specific needs of the owner. The BECxA must have the verbal and written communication skills necessary to assist with specification writers and drafters of other written documents and members of the design team to fully integrate the concept of BECs into the project documents. The BECxA should be fully aware of the critical aspects of the construction process to assist with constructability, flow of information, project documentation, project scheduling, implementation of QA/QC programs, third-party observations and testing, and finally, punch list development and closeout.

The commissioning process, when fully and comprehensively implemented, has been proven to be very successful in early detection of problems within the construction period, identifying and solving issues prior to building occupation. The process has proven the value of teamwork and collaboration, focusing on a proven end product that has been documented to meet primary design criteria. Fully implemented, the process can reduce potential for litigation by creating a transparent and verifiable record of the installations and testing protocols to document performance.

Standards and guides are continuing to evolve to further define the process and establish the specific role and function of the BECxA. The evolution process should include a greater and better-defined role for the contractor, including the further development of templates for the specific phases and processes that will eventually lead to a universal approach to BECx. Templates, however, will only provide outlines and guidelines that will require a strong coordinator to assist in the development of the OPRs, the particular nuances of each individual project, and the implementation within the project documents.

The development of ASTM E2813-12 has developed a framework for the expansion of a process that began with HVAC and has extended to the building envelope. The same process has clear value in other aspects of construction, though at a cost to the owner. While the added costs may be justified by the reduction in claims and potential remediation of issues soon after building turnover, the owner must assess the added costs and see the value in the process. The combination of the HVAC and envelope elements as a beginning platform should, if properly executed, provide clear justification for the expansion of the concept into additional elements of construction.

More work is needed in the development of the process and the roles of each of the professionals involved in both design and construction. This will take a number of years and the commitment of an industry to prove the overall process is effective and worthwhile.
REFERENCES

FOOTNOTES
2. ASTM E-2813, Standard Practice for Building Enclosure Commissioning (BECx).
4. WUFI-Oak Ridge National Laboratory (ORNL)/Fraunhofer IBP is a PC program which allows realistic calculation of the transient hygrothermal behavior of multilayer building components exposed to natural climate conditions.
5. Architectural programming is the research and decision-making process that identifies the scope of work to be designed.
6. BECxA refers specifically to the individual or firm retained by the owner to develop, manage, and be responsible for the BECx process, including individuals and technical specialists that may comprise the BECx team.
9. The “architect of record” is the architect or architecture firm whose name appears on a building permit issued for a specific project on which that architect or firm performed services.
10. The “plan of record” is an informational tool designed to define the requirements for the project.