



Designation: E2947 – 14

# Standard Guide for Building Enclosure Commissioning<sup>1</sup>

This standard is issued under the fixed designation E2947; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 *Purpose*—This guide provides procedures, methods and documentation techniques that may be used in the application of the building enclosure commissioning (BECx) process. This guide is complementary to Practice E2813 and is aligned with ANSI/ASHRAE/IES Standard 202 and ASHRAE Guideline 0.

1.2 *Extent*—The process outlined in this standard guide applies to each building delivery phase from pre-design through Owner occupancy and operation. The specific application of this guide may vary to suit the Owner, the project delivery method and the building project as outlined in the Owner's Project Requirements (OPR).

1.3 *Primary Focus*—The primary focus of this process includes, but may not be limited to, new construction of building enclosures, existing building enclosures undergoing substantial renovation or alteration, and continuous commissioning of enclosure systems.

1.4 *Contractual and Regulatory Obligations*—The methods described in this guide are not intended to supersede or otherwise replace the contractual obligations reserved specifically for the parties responsible for the design and construction of a building or structure, nor to alter the roles, responsibilities and duties that may otherwise be assigned to those parties by applicable regulatory or statutory law.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

E631 Terminology of Building Constructions

E2813 Practice for Building Enclosure Commissioning

### 2.2 ASHRAE Guidelines and Standards:<sup>3</sup>

ANSI/ASHRAE/IES Standard 202 Commissioning Process for Buildings and Systems

ASHRAE Guideline 0 The Commissioning Process

## 3. Terminology

3.1 *Definitions*—Refer to the most current edition of the following:

3.1.1 ASTM E631 Terminology of Building Constructions.

3.1.2 ASHRAE Guideline 0, Section 4, Definitions.

3.1.3 ANSI/ASHRAE/IES Standard 202, Section 3, Definitions.

### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 The following definitions, abbreviations, and acronyms are specific to the implementation of the commissioning process for building enclosure systems. These definitions are applicable throughout this guideline. Terms that are not defined have their ordinarily accepted meanings within the context in which they are used.

3.2.2 *basis of design, BOD, n*—a document developed by the design team that records the technical concepts, assumptions, calculations, decisions, and product selections used to meet the Owner's Project Requirements and to satisfy applicable regulatory requirements, standards and guidelines.

3.2.2.1 *Discussion*—The BOD document includes both narrative descriptions and lists of individual items that supports the design process.

3.2.3 *bidding and negotiation phase, n*—preparatory phase of the construction process delivery that assists in the solicitation and selection of prospective bidders, including evaluation of requests for information, substitutions, development of Addenda, review of bids and qualifications and the award of trade contracts.

3.2.3.1 *Discussion*—This phase is followed by the pre-construction sub-phase.

3.2.4 *building enclosure, n*—the terms “building enclosure” and “enclosure” refer collectively to materials, components, systems, and assemblies intended to provide shelter and environmental separation between interior and exterior, or

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329, <http://www.ashrae.org>.

between two or more environmentally distinct interior spaces in a building or structure.

3.2.4.1 *Discussion*—The building enclosure may include but is not limited to walls, fenestration, roofs, ceilings and floors (and the intentional openings and penetrations through them).

3.2.5 *building enclosure commissioning, BECx, n*—architecture or engineering-related technical services or both, performed on behalf of the Owner that implements a quality-focused process for enhancing the delivery of a project by focusing on validating during the design phase and verifying during the construction phase that the performance of building enclosure materials, components, assemblies and systems are designed and installed to meet the Owner’s Project Requirements.

3.2.6 *building enclosure commissioning plan, BECx plan, n*—a document that outlines the scope, organization, schedule, allocation of resources, responsibilities, testing and documentation requirements of the building enclosure commissioning process to meet the OPR.

3.2.6.1 *Discussion*—The BECx plan may be a portion of the whole building Cx plan.

3.2.7 *building enclosure commissioning provider, BECxP, n*—a duly authorized person or firm in the jurisdiction of the project retained by the Owner to develop, manage, and be in responsible charge of the BECx process, including the BECx activities from individual members and technical specialists that may comprise the BECx team.

3.2.7.1 *Discussion*—The BECxP should be trained, experienced, certified and knowledgeable in the building enclosure commissioning process, and possess and be able to demonstrate proficiency in the core competencies listed in 4.2.1 of Practice E2813. The person or firm performing the role of BECxP should be identified by the Owner. The role of the BECxP may be performed by the Building Enclosure Commissioning Specialist (BECxS), the overall building commissioning authority (CxA), or another qualified member to the Cx team.

3.2.8 *building enclosure commissioning specialist, BECxS, n*—a registered design professional (Professional Engineer or Registered Architect) and/or duly authorized firm in the jurisdiction of the project, who is retained by the Owner with the applicable experience, certification and technical knowledge of the performance of building enclosure systems and who is able to demonstrate and maintain throughout the project third party independence in order to avoid conflicts of interest.<sup>4</sup> Refer to 1.4 for additional information.

3.2.8.1 *Discussion*—The BECxS possesses the experience and technical skills needed to assess, critique, validate, verify, and support the BECx team during the design and construction phases.

3.2.9 *building enclosure commissioning team, BECx team, n*—the individuals and agencies who, through coordinated

actions, are responsible for implementing the Building Enclosure Commissioning Process.

3.2.9.1 *Discussion*—This group may be comprised of the Owner, Architect, Engineer, BECxP, BECxS, BECxT, design sub-consultants, construction manager, general contractor, subcontractors, manufacturers, and the whole-building CxA.

3.2.10 *building enclosure commissioning technologist, BECxT, n*—individuals and/or accredited testing agencies who possess the skills, knowledge, experience and certification, as required,<sup>4</sup> to perform the testing outlined in the building enclosure commissioning specification.

3.2.11 *commissioning authority, CxA, n*—entity identified by the Owner who leads, plans, schedules, and coordinates the commissioning team to implement the commissioning process for the whole building as outlined in ANSI/ASHRAE/IES Standard 202.

3.2.12 *commissioning plan, Cx plan, n*—document that outlines the organization, schedule, and allocation of resources, responsibilities, and documentation requirements of the whole building commissioning process.

3.2.13 *completion (substantial), n*—is as defined by the contract documents but generally understood to be the stage in the progress of the construction work where the project, or a portion of the project, is sufficiently complete that the Owner can occupy the building or utilize the building for its intended use.

3.2.14 *construction phase, n*—the period of the project delivery process after the construction contract is awarded.

3.2.14.1 *Discussion*—While there may be a variety of sub-phase names used in the industry, for this guide the following terms will be used for the sub-phases: pre-construction and construction administration.

3.2.14.2 *pre-construction sub-phase, n*—the period of the project delivery process after construction contract is awarded when enclosure systems and assemblies are detailed in shop drawings and laboratory or other quality assurance testing is performed prior to construction to comply with the construction documents and OPR.

3.2.14.3 *Discussion*—This sub-phase is followed by the construction administration sub-phase.

3.2.14.4 *construction administration sub-phase, n*—the period of the project delivery process when project enclosure materials are fabricated, installed, inspected, field tested, and placed into service to meet the Owner’s Project Requirements.

3.2.15 *design phase, n*—the period of the project delivery process when a design that satisfies the Owner’s Project Requirements is developed and translated into construction documents.

3.2.16 *design sub-phases, n*—design phase is typically<sup>5</sup> broken into three sub-phases with each taking approximately one third of the total design phase time to complete.

<sup>4</sup> The authority having jurisdiction may have more stringent requirements and qualifications for person’s performing this role.

<sup>5</sup> The sub-phases described are for a traditional project delivery process. While recognizing that a building can be designed and constructed following alternative project delivery processes (such as “design build” or “design assist”), this guide does not specifically address them.

3.2.16.1 *Discussion*—These design sub-phases have a variety of names, but for this guide, the following terms will be used:

3.2.16.2 *schematic design (also referred to as “35 % design”)*, *SD, n*—sub-phase of building design that produces documents that illustrate and describe the concept design of a project illustrating the scale and relationship of the project components including preliminary selections of major building systems and construction materials.

3.2.16.3 *Discussion*—Schematic design is followed by the design development sub-phase.

3.2.16.4 *design development (also referred to as “65 % design”)*, *DD, n*—sub-phase of building design that produces documents that illustrate and describe the refinement of the schematic design of a project establishing the scope, relationships, forms, size, and appearance of the project. Major materials and systems are identified including interface details and their quality levels are established.

3.2.16.5 *Discussion*—Design development is followed by the construction documents subphase.

3.2.16.6 *construction documents (also referred to as “100 % design”)*, *CD, n*—sub-phase of building design that produces documents that (1) set forth in detail the requirements for the construction of a project and (2) establish in detail the enclosure performance requirements and the quality of materials and systems required for the project.

3.2.16.7 *Discussion*—Final construction documents are prepared as required to solicit, procure, and construct the project and include drawings, specifications, contract forms and conditions, bidding requirements, and resource documents (see definitions of Construction Documents in ANSI/ASHRAE/IES Standard 202).

3.2.17 *independent 3rd party design peer review, IDR, n*—objective technical review of the design and/or construction documents that, as part of the BECx process during the design phase, evaluates the proposed building enclosure systems, details, objectives and performance criteria for compliance with the OPR.

3.2.17.1 *Discussion*—The IDR is performed by the BECxS.

3.2.18 *nonconformance process, n*—process for identifying, documenting, evaluating, and avoiding the inadvertent use or installation of nonconforming items of work.

3.2.18.1 *Discussion*—Construction materials and systems that are found not to be in compliance with the approved project requirements, specifications, drawings and referenced standards and that render the quality of the materials or systems unacceptable or indeterminate requires the generation of a nonconformance report (NCR).

3.2.18.2 *Discussion*—Nonconformances typically include:

- (1) Physical defects in materials, assemblies and workmanship;
- (2) Failures of required tests;
- (3) Incorrect or inadequate documentation; and
- (4) Departures from specified or previously approved work processes, inspection, or testing procedures.

3.2.19 *owner’s project requirements, OPR, n*—a written document that details the Owner’s vision and requirements of

a project and the expectations of how it will be used and operated and includes the programmatic, aesthetic, and general performance requirements of a building, structure or portion thereof and the expectations of the Owner relative to its intended use, occupancy, operation, and service life.

3.2.19.1 *Discussion*—The portion of the OPR that relates to the building enclosure is considered to be a “living document” for the BECx process and outlines the objectives upon which the pre-design, design, and construction phase BECx activities are evaluated (see definitions in ANSI/ASHRAE/IES Standard 202).

3.2.20 *pre-design phase, n*—preparatory phase of the project delivery process in which the OPR is developed and the BECx scope is outlined.

3.2.20.1 *Discussion*—This phase is followed by the schematic design sub-phase.

3.3 *Abbreviations and Acronyms:*

3.3.1 *A/E*—Architect/Engineer

3.3.2 *AOR*—Architect of Record

3.3.3 *BECx*—Building enclosure commissioning

3.3.4 *BECxP*—Building enclosure commissioning provider

3.3.5 *BECxS*—Building enclosure commissioning specialist

3.3.6 *BECxT*—Building enclosure commissioning technologist

3.3.7 *BOD*—Basis of design document

3.3.8 *Cx*—Commissioning

3.3.9 *CxA*—Commissioning authority

3.3.10 *IDR*—Independent 3rd party design peer review

3.3.11 *NCR*—Nonconformance report

3.3.12 *OPR*—Owner’s project requirements

3.3.13 *QA*—Quality assurance

3.3.14 *QC*—Quality control

3.3.15 *Design Phases:*

3.3.15.1 *SD*—Schematic design phase (or 35 % design phase)

3.3.15.2 *DD*—Design development phase (or 65 % design phase)

3.3.15.3 *CD*—Construction document phase (or 100 % design phase)

## 4. Summary of Practice

4.1 The process of commissioning the enclosure follows a similar process as commissioning other building systems but with a focus on the design and construction of materials, systems, and assemblies that comprise the building enclosure. The BECx process begins as early as pre-design with the establishment of the Owner’s Project Requirements (OPR) and runs in parallel to project delivery process to ensure that the building enclosure meets or exceeds the expectations of the Owner, as defined in the OPR. The enclosure is typically designed, assembled, and installed using numerous materials with varying properties and supplied by independent contractors and subcontractors. Enclosure components may be installed in varying weather conditions on-site and in a sequence

or manner that does not provide ready access to inspect, maintain, or repair them after the building is complete. The BECx process includes site observation and testing that should be performed periodically<sup>6</sup> throughout the installation of the enclosure subsystems and components. The BECx process is not intended to replace QA/QC processes (including inspections, checks and/or tests) that the contractor should perform to ensure that the product furnished and installed meets their contractual obligations.

**4.2 Third-Party Independence**—The BECxP and BECxS, who are retained by the Owner, should be able to demonstrate and maintain throughout the project third party independence in order to avoid conflicts of interest. The BECxP and BECxS should have no contractual relationship to any firm providing design or construction related services to the project and have no known or potential conflicts of interest.<sup>7</sup> The BECxP and BECxS should disclose to the Owner existing relationships with other parties on the project. The disclosure should occur when the BECxP and BECxS are retained as well as at appropriate intervals including when other firms and individuals are engaged in the project.

**4.3 Levels of BECx**—The ASTM Standard Practice for Building Enclosure Commissioning (E2813) defines two levels of building enclosure commissioning – fundamental BECx and enhanced BECx. The standard practice describes the similarities and key difference between the two levels of BECx. The key differences include (1) the latest starting point to begin BECx process within the overall project delivery process, (2) the minimum number of mandatory IDR(s) required during the design phase and (3) the amount of mandatory testing required during the pre-construction and construction phases. While fundamental BECx need not start at pre-design, early process engagement may be advantageous. For fundamental BECx, the BECxP should be engaged during the Design Phase and no later than the commencement of the Design Development sub-phase. For enhanced BECx, the BECxP should be engaged during the predesign phase. Fundamental BECx requires a minimum of one IDR of enclosure related documents including drawings and specifications while enhanced BECx requires a minimum of three such IDR(s) during the design phase. While both levels of BECx require first installation mock-ups as a minimum requirement, enhanced BECx requires either a pre-construction laboratory mock-up or on-site free standing-building mock-up to be tested. The scope and number of field testing is greater for enhanced BECx in comparison to fundamental BECx—refer to Practice E2813 (Table 2.1).

**4.4** This guide describes a process that Owners may follow to incorporate building enclosure commissioning (BECx) into their project. The most effective commissioning process begins at project inception (during the predesign phase) and may continue into the occupancy and operations phase.

<sup>6</sup> Where these inspections and tests are being performed to satisfy regulatory requirements for the authority having jurisdiction (such as Special Inspections), those requirements for inspection and testing that may differ from those in this BECx guide and may be more stringent.

<sup>7</sup> The laws in the jurisdiction of the project may have more stringent or specific conflict of interest and independence requirements than those outlined in this standard guide.

**4.5** The commissioning team is guided by the Owner’s Project Requirements (OPR). It is drafted at the inception of a project and is referred to throughout the life of the project. As building systems are often integrated and interconnected, a performance deficiency in the building enclosure can result in less than optimal performance in other systems. For optimal performance, the building’s commissioning team (Cx team), in the various systems to be commissioned, should include cross-disciplinary understanding of related systems with a thorough technical knowledge of their specific area of responsibility. The commissioning team is assembled at the predesign phase and can be augmented as the design and construction process progresses and as the building requirements are established.

**4.6** Predesign is one of the preparatory phases of the project delivery process. The Owner’s initial concepts, objectives, and desires for a given project are documented in the OPR. Refer to OPR Development Guideline in Practice E2813, Annex A1. During predesign, the BECxP should draft a preliminary BECx plan to establish the BECx team and propose a preliminary scope for BECx activities and BECx budgets for the various phases of the project for the Owner’s review and approval.

**4.7** During the design phase, the BECx activities include the IDR(s) of the design documents and coordination of the building enclosure requirements among the BECx team members. Throughout this phase, the objectives of the OPR are further defined to reflect the Owner’s decisions and changes. A project-specific BECx specification is developed by the BECxP for inclusion into the project manual once accepted by the Owner and Architect of Record.

**4.8** During the bidding and negotiation phase, the BECx team members review the BECx process with the prospective bidders and are involved in the technical evaluation of contractor/subcontractor proposals. The BECxS reviews technical proposals and assists with the technical evaluation of bids to meet the requirements of the OPR, inclusive of performance-impacting qualifications, substitutions and exclusions, schedules, phasing, coordination, quality assurance/quality control (QA/QC) programs, and value-engineering proposals.

**4.9** During the construction phase, the contractors, specialty subcontractors, 3rd party inspection and testing agencies are also engaged in the commissioning process. The BECx process incorporates tasks throughout the construction phase, that are specific to the project delivery method being employed on that project, including but not limited to: attending a preconstruction meeting, the review and comment on building enclosure technical submittals and shop drawings, participating in periodic commissioning meetings, conducting and witnessing laboratory testing, attending pre-installation ‘kickoff’ meetings, monitoring construction of site ‘first installation’ or ‘benchmark’ mockups, auditing the contractor’s QA/QC program including implementation of project specific checklists, performing periodic construction observation visits to the fabrication shops and to the site, and conducting and witnessing on-site performance testing. These BECx activities focus on

verifying that the installed work complies with the construction documents and the OPR.

4.10 At the start of the occupancy phase, BECx activities include organizing a handover meeting of the systems manual and BECx final report to the Owner, verifying that training of the Owner’s representatives occurs in the operation and maintenance of the building enclosure. Further along in this phase, a review of the performance history of the building enclosure materials, components, and assemblies should be done and a condition assessment performed prior to the conclusion of the initial warranty period.

## 5. Significance and Use

5.1 This guide provides recommendations for the enclosure commissioning process from its project planning through design, construction and occupancy and operation phases. This guide is intended for various building types. Although Practice E2813 defines two levels of commissioning, fundamental and enhanced, complex buildings and Owners seeking a higher level of assurance may require more intensified commissioning than the minimum requirements described in this guide and Practice E2813.<sup>8</sup>

5.2 The process uses performance-oriented practices and procedures to verify that the project is achieving the OPR throughout the delivery of the project.

5.3 The BECx process is recommended to begin during the predesign phase and continues through the occupancy and operations phase. The process includes specific tasks during each project phase.

5.4 The commissioning process is outlined in ANSI/ASHRAE/IES Standard 202. It is recommended that the reader understand and comprehend the base process provided in that document. This standard guide and Practice E2813 provide a specific process related to the building enclosure commissioning.

5.5 Note that the commissioning process should not infringe upon the authority or responsibility of the Owner, the project’s designers or contractors. The BECxS, BECxP and CxA can identify areas of concern relative to the Owner’s Project Requirements which are discussed with the Owner and other stakeholders; however it is the Owner who directs the project and BECx teams. It is recommended that the BECxP be engaged in predesign phase to define the scope of commissioning so that the Owner’s agreements with the project team (including the contractor) clearly define the scope of contracted tasks that interface with commissioning process.

5.6 Commissioning does not replace a traditional design/construction process but is meant to enhance and be an integral part of that process by validating the design and verifying the construction meets the requirements of the OPR.

5.7 In this guide, the performance objectives for attributes of the building enclosure as required by an Owner are

<sup>8</sup> This guide anticipates that the BECxS in some jurisdictions may provide, where qualified, certified and/or accredited to do so, 3rd party inspection services and regulatory sign-offs (for example, Special Inspection) on behalf of Owner and the authority having jurisdiction.

considered. Enclosure attributes to be considered include the control of moisture, condensation, heat flow, air flow, water vapor flow, noise, fire, vibrations, energy, light, infrared radiation (IR), ultraviolet radiation (UV), as well as the structural performance, durability, resiliency, security, reliability, aesthetics, value, constructability, maintainability over its life cycle, and sustainability of the enclosure elements, to meet the OPR. The commissioning objectives for a building’s enclosure may vary by the Owner’s requirements. The objectives contained in the OPR may vary by occupancy, use, size, and the project requirements, which may include other requirements across these or other variables.

5.7.1 Note that this guide is not a one-size-fits-all “how to” standard guide on avoiding poorly performing building enclosures.

### 5.8 Approach:

5.8.1 The sequence of work for the commissioning team commences by assembling the documentation of the OPR at the inception of a project. The sequence continues with the conveyance and interpretation of this information by the BECx team members throughout the building delivery process. Throughout the process, the BECxP verifies that the BECx team’s work product is consistent with this guide and Practice E2813. The commissioning process has been structured to coincide with the phases of a generic project with predesign, design, bidding and negotiation, construction, occupancy, and operations phases. If circumstances require Owners to adopt the commissioning process during the design or construction phase of a project, implementation at that point in time shall capture the information that would have been developed had the commissioning process begun at project inception. Beginning the building enclosure commissioning process at project inception will maximize benefits to the project.

5.8.2 Although this guide focuses upon building enclosure systems, a successful whole building commissioning process should carefully document and verify interfaces between interdependent building systems. Even if the building enclosure is the singular focus of this Cx process, coordination among disciplines is essential for overall building project success.

## 6. Predesign Phase

### 6.1 Introduction:

6.1.1 Predesign is a preparatory phase of the project delivery process in which the OPR is established and general information about the overall project is gathered.

6.1.2 The OPR developed during predesign should be recognized as a starting point for subsequent design phases. The OPR will continue to evolve during the design phases to respond to evolving design, cost and schedule information as directed by the Owner.

6.1.3 *BECx Activity Objectives* include:

6.1.3.1 Attend project planning conference(s) (or “kickoff meeting(s)”);

6.1.3.2 Document the OPR;

6.1.3.3 Select a level of Building Envelope Commissioning (either Fundamental or Enhanced) and identify a scope and budget for the commissioning process;

6.1.3.4 Communicate commissioning requirements to the Owner for inclusion in agreements including those between the Owner and design team;<sup>9</sup>

6.1.3.5 Initiate development of the commissioning plan; and

6.1.3.6 Provide predesign phase BECx progress summary report.

### 6.2 *BECx Kickoff Meeting:*

6.2.1 Commissioning activities in the predesign phase begin with a kickoff meeting. The agenda of this meeting includes identification of project objectives and discussion of the project's commissioning process. The agenda may include:

6.2.1.1 An introduction to the BECx process, including the various tasks and objectives of each phase;

6.2.1.2 The project delivery method and the extent to which the various building systems will be commissioned; and

6.2.1.3 Basic design objectives, including the functional and programmatic requirements for the project, targets for energy usage and facility life-cycle requirements.

### 6.2.2 *Commissioning Team Members and Responsibilities:*

6.2.2.1 The BECx team is comprised of members of the project team assigned the responsibility for the implementation of the commissioning process. The BECx team is typically established by the Owner to oversee and accomplish the tasks outlined in this guide. A CxA is designated by the Owner to supervise the overall building commissioning process. The BECxP may be retained by the Owner directly or be assigned by the CxA if duly authorized to do so by the Owner. The BECx team includes a BECxS to provide technical expertise and participate in the commissioning process as outlined in this guide. The BECxP and BECxS may assist the Owner in the development of the OPR. Inclusion of additional team members, such as the Architect and pre-construction manager may be included as appropriate.

6.2.2.2 The make-up of the project's BECx team may likely change throughout the project duration to adapt to the shifting emphasis of the project's demands; however, representation of the BECxP and BECxS should remain consistent.

6.2.2.3 Responsibilities for the BECx team include:

(1) Facilitate the incorporation of the Owner's building enclosure objectives into the OPR;

(2) Establish the protocols for documentation;

(3) Establish BECx plan, scope, and budget; and

(4) Verify the roles and responsibilities for each member of the BECx team and understand the nature of the commissioning tasks and how these tasks may impact each independent team member or trades' scope of work.

### 6.3 *OPR Document:*

6.3.1 The predesign phase OPR document may include:

(1) A building enclosure vision, including any Owner's directives, restrictions or limitations, durability expectations, and building enclosure service life expectancy;

(a) *Discussion*—The Owner may wish to achieve building enclosure performance objectives/requirements beyond basic code and should consider items such as, but not limited

to, increased energy efficiency, environmental and sustainability goals, serviceability, adaptation for future expansion, integration of systems, indoor environmental requirements, acoustics, security, or communications.

(2) Building enclosure requirements (for example, functional and programmatic requirements, material preferences, general performance objectives, initial enclosure cost budgets, and facility interior condition requirements);

(3) Community context (for example, neighboring buildings that can be impacted by the project; disruptive noise generation, historic district requirements);

(4) Site information and interior and exterior climate conditions;

(5) Occupant comfort and productivity requirements;

(6) Scheduled maintenance requirements;

(7) Sustainability Goals: incentives, energy use targets, environmental label targets;

(8) Other Owner requirements, such as insurance company requirements, facility guidelines, or preferred systems/manufacturers; and

(9) "Lessons learned" from previous BECx projects.

### 6.4 *Identify the Scope and Budget for the BECx Process:*

6.4.1 To facilitate the choice of either Fundamental or Enhanced levels of BECx, preliminary BECx budgets and schedules should be developed to include preliminary estimates of the costs and time required to accomplish the commissioning process activities including, but not limited to:

6.4.1.1 The activities of the commissioning team during the building design, construction, and occupancy phases;

6.4.1.2 The recommended number of IDRs; and

6.4.1.3 Preliminary scope and estimates for laboratory mockup and field mock-up testing. Preliminary costs for functional performance testing will be established to determine the anticipated level of BECx effort, including expected frequency of laboratory mockups, field mockups, visits to production facilities during fabrication, site visits during initial installation and/or at various stages throughout construction. The accuracy of the scope and estimates will depend on the state of the conceptual building enclosure design during predesign.

6.4.2 *Selecting a Level of BECx*—Many factors must be taken into account by the Owner in selecting either fundamental BECx or enhanced BECx for a given project. This decision should be made by the Owner in consultation with the BECxP and other project stakeholders. Some of the factors that should be considered in this decision include: any code, ordinance or legislation that may require a specific level of BECx (if any); incentive program or sustainability/environmental label target (such as LEED) that may have requirements for a specific level of BECx; the type of construction and the likely method of project delivery (such as design-build, design-bid-build or design-assist); the project environment and its location; the intended use and occupancy-use of the building; the design-construction schedule for the project; the Owner's budget; the Owner's expectation for both level of quality and tolerance for risk; the track record and experience level of the likely contractors to perform the work envisioned; and/or the track

<sup>9</sup> The commissioning requirements for contractor agreements should be discussed with the Owner where early award of enclosure trade contracts are anticipated (such as, in a design-build or design-assist delivery process).

record for the building enclosure systems or components that are likely to be selected.

**6.5 BECx Plan**—The BECx plan identifies the processes and procedures necessary to achieve the desired level of BECx—either fundamental or enhanced BECx. This will include verifying that the minimum level of IDR and testing is incorporated into the BECx plan. The plan should respond to the project specific OPR; the Owner’s risk management strategy; and overall complexity of the building enclosure design and performance requirements. The BECx plan is to be reviewed and updated throughout the project. The BECx plan, as part of the whole building Commissioning Plan, should define:

**6.5.1** The roles and responsibilities of the project team members performing BECx, including tasks that are to comprise the process. These tasks should be project specific and be consistent with the minimum requirements of Practice **E2813**. The BECx plan should maintain the focus on achieving the OPR.

**6.5.2** The preliminary communication protocols and methods for distribution of information among the BECx team.

**6.6 Prepare Commissioning Process Progress Report:**

**6.6.1** The BECxP should provide a summary report outlining the BECx activities, process and work products developed during the pre-design phase.

**6.6.2** The BECx progress report should be included in the Final BECx Report.

## 7. Design Phase

**7.1 Introduction**—The design phase includes BECx activities to validate that the Architect’s BOD document responds to and reflects the OPR and verifies that the plans and specifications developed throughout the design phase are consistent with the OPR. The IDRs are performed and documented by the BECxS. Team meetings are held to review and discuss building enclosure system and material selection and how their performance meets the requirements of the OPR. The BECx plan is further refined and the project-specific BECx specification is drafted and provided to the AOR for acceptance and inclusion in the project manual. This section provides BECx activity guidance for each of three sub-phases of design—schematic design (SD), design development (DD) and construction documents (CD).<sup>10</sup>

**7.1.1 Independent Technical Design Reviews (IDRs)**—While the minimum number of IDRs are prescribed in Practice **E2813** for each level of BECx, selecting the appropriate point within the design phase and subphases when the IDR(s) should occur is a judgment call by the Owner with input from the BECxP, Architect, BECxS and other BECx team members as appropriate. The IDRs should be performed in a manner that will allow for the timely review and consideration by the AOR. IDR performed earlier in the design process may provide distinct benefits as variations from the OPR and other technical

concerns raised during the review can be flagged and resolved expeditiously while minimizing the negative impact to the project.

**7.2 Schematic Design (SD):**

**7.2.1** In this preliminary sub-phase, BECx activities occur in parallel with the designer’s process where the concept design is further developed and various enclosure options are considered and compared on their technical and other merits. The review of enclosure options should evaluate the impact on budget and schedule for associated commissioning activities. Each building enclosure system option may have specific tests and tools available for qualitative or quantitative analysis of performance, or both, with varying degrees of certainty.

**7.2.2 SD BECx Meeting**—If a substantial gap in time has occurred from the predesign phase meetings, SD should begin with members of the BECx team participating in a meeting to review the OPR developed during pre-design<sup>11</sup> and the objectives for commissioning of the building enclosure as described in the pre-design BECx plan.

**7.2.3 SD Basis of Design Review**—The BECxS should coordinate the review of the Architect’s BOD document to check that systems outlined in this document provide an appropriate design solution to fulfill the OPR requirements, both for enclosure requirements and integrating the enclosure with other building systems. The BOD should include narrative descriptions of building exterior and interior enclosure systems (for example, roof, exterior walls, floors, windows, skylights, atria, ceiling under, floor over or wall adjacent to unconditioned space, and so forth).

**7.2.4 SD Independent Technical Design Review (IDR):**

**7.2.4.1** The BECxS should perform the IDR of building enclosure related SD documents for consistency with the OPR. This review may include the alternative enclosure schemes for appropriateness and compliance with the OPR.

**7.2.4.2** The IDR should include the evaluation of the proposed concepts of the building enclosure and preferred materials as prepared by the Architect with the OPR requirements. The review should be undertaken for the building enclosure as described in the SD documents.

**7.2.4.3** The IDR report should advise the Architect, Owner and other BECx team members on technical performance related concerns found in the SD documents including but not limited to missing or incomplete details or unidentified building enclosure components; areas of concern related to performance and constructability, details requiring further study or analysis to confirm compliance, conditions noted on the drawings where proper sequence and coordination are needed, and other undefined information related to the building enclosure components, system, performance or function. The report and any written comments on documents from the IDR should be issued as a formal Cx deliverable to the Architect, Owner and distributed to BECx team members as appropriate. These comments should be reviewed and responded to by the Architect. The response may include the Architect modifying

<sup>10</sup> While this guide follows a traditional project delivery process, some flexibility may be warranted in applying the provisions from different sub-phases to suit the project and project delivery method selected.

<sup>11</sup> The retroactive development of a written OPR may be required in SD phase where a formal OPR may not exist or otherwise was not fully developed during the pre-design phase of the BECx process.

or revising SD documents as required for consistency with the OPR or suggesting to the Owner a change to the OPR. Variations from the OPR noted in the peer review process that are not reconciled should be entered in the Cx issue and resolution log.

**7.2.5 Evaluate and Update the Building Enclosure Criteria in the OPR:**

**7.2.5.1** At intervals during the SD phase, the BECx team should compare building enclosure documents and system alternatives developed by the design team against the OPR.

**7.2.5.2** The BECxP should recommend OPR updates to the Owner as criteria are developed. The OPR should be updated and expanded with explanations and changes recorded to document decisions.

**7.2.6 SD BECx Plan:**

**7.2.6.1** The BECx plan, among other objectives, helps the Owner understand the requirements and risks associated with each enclosure system in delivering the anticipated level of performance and the cost and schedule impact of the commissioning activities.

**7.2.6.2** The BECxP should update and expand the preliminary BECx plan outlined in pre-design in parallel with the examination of alternative schematic concepts for building enclosure systems, the selection of preferred systems from the alternatives, and the design of the selected systems. The BECxP should ensure the BECx plan is coordinated with the OPR and BOD.

**7.2.7 BECx SD Report and Issues and Resolution Log**—The BECxP should provide to the Owner a Cx progress report and issues and resolution log at end of the SD phase. The BECxP should conduct a BECx review meeting to address whether the BECx objectives for the SD phase have been met. Unresolved issues should be documented, and the resulting issues log becomes a resource for beginning the subsequent design sub-phase—Design Development. The BECx SD Report is included in the Final BECx Report.

**7.3 Design Development (DD):**

**7.3.1** In this design sub-phase, the concept of the building is well enough established to allow progression of the building enclosure design by the design team, and as defined in the Architect’s basis of design (BOD). In this sub-phase, more detailed drawings, large-scale wall sections, elevations and details, and preliminary specifications for the building enclosure systems and testing requirements are developed in support of the design concept and BOD. The DD documents are reviewed by the BECx team against the OPR.<sup>12</sup> The OPR is updated to reflect decisions made during DD.

**7.3.2 DD BECx Meeting:**

**7.3.2.1** If a substantial gap in time has occurred from the SD phase meetings, DD should establish a BECx team meeting to review the objectives for commissioning of the building enclosure.

**7.3.2.2** During DD, comparisons of various system options for the building enclosure systems should be conducted by the

A/E and reviewed by the BECxS. For each enclosure system option, variations between options should be considered including balanced comparisons of cost, performance, and aesthetics. The BECxS evaluates the system options presented in the DD documents for conformance with the OPR. During DD, the BECxP and BECxS should provide the BECx team with an updated BECx plan that includes the proposed BECx activities and interactions between the BECx team members. The updated BECx plan should include a proposed scope of testing that should be used in the development of a preliminary outline BECx specification. At completion of DD, assemblies that comprise the building enclosure, including those below grade, should be identified in the documents with enough specificity to define the assembly with functional layers identified. Air, water, thermal, and vapor control layers should be identified, as well as the means by which they are intended to meet the criteria included in the OPR.

**7.3.2.3** A determination and hierarchical analysis of the options should be compiled by the BECxS to balance objectives in the OPR and facilitate a decision between various options by the Owner. Methodologies for calculating and verifying how each system option fulfills the OPR requirements should be determined. An analysis of the impact on the durability, resiliency, sustainability and cost over the service life of the building for each enclosure option should be performed and communicated with the Owner.

**7.3.2.4** The BECxP and BECxS should attend regularly scheduled BECx meetings with the project team during DD at milestone intervals appropriate for the project.

**7.3.3 DD BOD Review:**

**7.3.3.1** The BOD outlined during the SD phase is updated and substantially completed by the Architect during DD. The BECxS should perform a review of the BOD to verify it includes a description of each system considered, such as type of building enclosure system, subsystems, materials and components, and the interaction of the building enclosure system with: the building superstructure, natural and mechanical ventilation systems, day lighting and artificial lighting systems, and other systems. The BOD should specifically describe how the design meets the building enclosure-related OPR.

**7.3.4 DD Independent Technical Design Review (IDR):**

**7.3.4.1** The BECxS should perform the IDR of DD documents including the BOD, details, and preliminary specifications for consistency with the OPR. The BECxS should be familiar with the status of the current issues and resolution log in order to effectively perform the IDR.

**7.3.4.2** The BECxS should review the DD drawings related to the building enclosure including typical and atypical interface details. Details to be reviewed should include, but not be limited to, typical details at the interface between: roof to wall, foundation to wall, fenestration, wall to floor, wall to column, penetrations, below grade waterproofing and other features that are common or highly repeated for the various enclosure system options. Certain atypical conditions within the building enclosure may require more focused review.

**7.3.4.3** The BECxS should verify in their review that the DD documents clearly identify the extent of each control layer.

<sup>12</sup> The retroactive development of a written OPR may be required in DD phase where a formal OPR may not exist or otherwise was not fully developed during the pre-design and schematic design phases of the BECx process.



The IDR should include a review of interface details for their performance, constructability and the continuity of the air, water, thermal, and vapor control layers. At each interface between systems including but not limited to window to wall, wall to foundation, and wall to roof, the BECxS should highlight with mark-ups on those details conditions of potential issue and concerns related to continuity, performance, constructability, durability and in-service maintenance. The technical design review report should highlight technical concerns; identify missing or incomplete details or missing information related to materials, systems and assemblies.

7.3.4.4 The BECxS should review the DD specifications during the IDR for compliance with the OPR. The BECxS should review the BECx specification to confirm that it outlines: the roles and responsibilities of the commissioning team during construction, the scope of testing and commissioning activities, provides a process for non-compliance resolution, documentation requirements throughout the BECx process and probable commissioning activities during the occupancy and operations phase, if any.

7.3.4.5 The BECxS should review the thermal and hygro-thermal analysis provided by the A/E or sub-consultants of various systems to confirm compliance with the OPR including the assembly U-factors and condensation resistance for each opaque enclosure systems and U-factors, solar heat gain coefficients, and visible light transmittances for the fenestration assemblies.

7.3.4.6 The BECxS should review the documents to determine whether they appear to be generally coordinated between related systems including structure; heating, ventilation, and air conditioning (HVAC); day lighting; and with the work of specialty design consultants who may have contributed to the design including but not limited to specialists in acoustics, blast mitigation, building maintenance and wind tunnel testing.

7.3.4.7 The BECxS should review and provide comments on the proposed scope of laboratory and field mockups, testing, and inspection procedures.

7.3.4.8 The BECxS should review the outline or draft DD specifications for preferred materials and systems, technical competency, coordination with DD details, and verify the inclusion of proposed commissioning activities.

7.3.4.9 The BECxS should evaluate the ability of each enclosure system identified for the capability of that system to satisfy the OPR and the appropriateness of use of that system within the overall design.

7.3.4.10 The design review report prepared by the BECxS should advise the Owner, Architect and BECx team on technical performance related concerns found in the documents reviewed including but not limited to missing or incomplete details or unidentified building enclosure components; areas of concern related to constructability; details requiring further study or analysis (to confirm compliance with the OPR); conditions noted on the drawings where proper sequence and coordination are needed for proper installation; and other missing information related to the building enclosure components, system, performance or function. The written comments and/or report from the IDR by the BECxS should be issued as a formal Cx deliverable to the Architect, Owner and

distributed to BECx team members as appropriate. The BECxP should conduct a BECx team meeting to review and address comments made in the IDR. The objective of this meeting is to resolve issues found during the peer review of the DD documents and have the Owner and Architect decide whether to revise either the DD documents or OPR with the goal that they be consistent. Outstanding open issues should be documented in the issue and resolution log.

7.3.5 *Evaluate and Update the OPR and BOD*—During DD, the BECxP and BECxS should recommend OPR updates to the Owner and BOD updates to the Architect including the specific quantitative performance values based on industry established standards for applicable performance characteristics. The requirements in the updated BOD should be complete and specific so that the DD level design can be verified to meet the OPR.

7.3.6 *DD BECx Plan*—During DD, the commissioning plan should be coordinated against the OPR and the BOD and further refined based on the building enclosure design. The extent of laboratory mockups with associated testing protocols; the number, size, and disposition of field mockups and field performance testing with associated testing protocols; independent 3rd party inspection (including special inspections) should be determined and included in the BECx plan and the associated BECx budget. Special recommendations for the CM's/contractor's quality programs as it interfaces with the BECx process should be written into the specifications. At the end of the DD phase, the BECxP should confirm that updates to the BECx plan have been incorporated. These DD updates to the BECx plan should include:

7.3.6.1 A list of systems to be documented and tested including frequency of testing; identifying the consequences of failure to meet performance requirements during testing that may include retesting and any increase in the frequency of testing or inspection after a failure;

7.3.6.2 Outline of inspection protocols and testing procedures with acceptance criteria; and

7.3.6.3 A preliminary schedule of building enclosure related commissioning process activities for (1) the construction phase and (2) the occupancy and operations phase. The schedule should identify critical times for witnessing testing activities, building enclosure system installation, and activities relative to substantial completion/project closeout.

7.3.7 *DD BECx Report and Issues and Resolution Log*—The BECxP should provide a BECx progress report and issues and resolution log at the end of the DD phase. The BECxP should conduct a project team review meeting to address whether the objectives for the DD phase have been met. Unresolved DD issues should be documented, and the resulting issues log should be a resource for beginning the construction document sub-phase. The BECx DD Report is included in the Final BECx Report.

#### 7.4 *Construction Documents (CD):*

7.4.1 During the CD phase, BECx activities coincide with the development of construction documents by the design team. The building enclosure systems and typical details selected in DD are fully developed by the design team for the specific interfacing conditions required on the project. In this

phase, the design team adds plan details and sections to the documents as appropriate along with comprehensive specifications and schedules. The construction documents become the delivery method of the OPR and are completed to a level of detail and specificity to allow for procurement and construction of a building that meets the OPR.

#### 7.4.2 *CD BECx Meeting:*

7.4.2.1 If a substantial gap in time has occurred from the DD phase meetings, CD should begin with members of the project BECx team participating in a meeting to review the objectives for commissioning of the building enclosure.

#### 7.4.3 *CD Independent Technical Design Review (IDR):*

7.4.3.1 The BECxS should perform the IDR of construction documents, including enclosure related drawings and specifications, for consistency with the OPR. The BECxS should start their IDR review by reviewing the OPR, BOD, the current issues and resolution log, and any previous IDR reports and comments.

7.4.3.2 The BECxS should review those construction documents necessary to complete the IDR of the building enclosure. The IDR should include the review of CD documents for its general completeness and the inclusion of sufficient details and information (including joints and interfaces between components and systems) to determine if the completeness and quality of the design information as presented is consistent with OPR and BOD requirements including for performance, durability, constructability and the continuity of the air, water, thermal and vapor control layers.

7.4.3.3 The BECxS should provide commentary on the expected or target heat/air/moisture performance presented in the documents including review of supporting numerical thermal and hygrothermal analysis provided by the A/E team.

7.4.3.4 The BECxS should review the documents to ascertain whether the building enclosure is generally coordinated with related systems including structure; heating, ventilation, and air conditioning (HVAC); day lighting. The reports and work product of specialty design consultants who may have contributed to the design should be reviewed including but not limited to acoustics, blast mitigation, building maintenance, wind tunnel testing and others, as applicable.

7.4.3.5 BECxS should review the technical specifications for materials and systems shown for appropriateness in meeting the OPR and to verify they are generally coordinated with the construction documents.

7.4.3.6 The BECxS should review the BECx specification for laboratory and field mock-up requirements and testing and inspection procedures to be used during the construction phase. BECxS should review the BECx specification to ensure it contains the commissioning process requirements, including but not limited to the requirements for: performance validation, submittals, testing, inspection, mockups, contractor's quality assurance (QA) program and end-user training.

7.4.3.7 The written comments and/or report from the IDR by the BECxS should be issued as a formal Cx deliverable to the Architect, Owner and distributed to BECx team members as appropriate. The BECxP should conduct a BECx team meeting to review and address comments made in the IDR. The objective of this meeting is to resolve issues found during the

peer review of the construction documents and determine whether the construction documents will be revised by the Architect or the OPR will be revised with the goal that they be consistent. The BECxP should document outstanding issues in the issue and resolution log that will become a resource for beginning the pre-construction and construction phases.

7.4.3.8 The BECxP and BECxS should attend regularly scheduled BECx meetings with the project team during CD at milestone intervals appropriate for the project.

#### 7.4.4 *Evaluate and Update the OPR and BOD:*

7.4.4.1 During the CD sub-phase, the BECxP should recommend OPR updates to the Owner and BOD updates to the Architect as the design is completed. Unless the design is substantially changed, the OPR should not require substantive changes during the CD sub-phase. Information regarding final material selections is updated and checked for coordination with other building enclosure materials and systems including accepted value-engineering changes.

7.4.4.2 The BECxS should reconfirm the ability of each enclosure system to satisfy the OPR and BOD and the appropriate use of that system within the overall design.

#### 7.4.5 *CD BECx Plan:*

7.4.5.1 During CD, the BECx plan that was prepared in the DD phase is updated and finalized by the BECxP. Revisions to the BECx plan should be coordinated with the commissioning activities of other systems in the building. Revisions to the BECx plan should be incorporated as needed into the final BECx specification by the Architect for inclusion in the project manual.

7.4.5.2 The BECxP should update the schedule of BECx activities for (1) the bidding and negotiation, (2) the construction phase and (3) the occupancy and operations phase. The schedule should identify times for BECx team meetings in bidding/negotiation and construction phases, witnessing testing activities, attendance at pre-installation conferences, building enclosure system fabrication, assembly and installation, and activities relative to substantial completion and project close-out.

7.4.5.3 The BECxP should update the BECx budget for BECx plan updates made during the CD sub-phase.

#### 7.4.6 *CD BECx Specification:*

7.4.6.1 The BECx specification is drafted by the BECxP and BECxS with input from other members of the BECx team and is submitted for review and final acceptance by the AOR for inclusion into the project manual. The BECxP should coordinate the BECx specification so it is consistent with the BOD including performance and testing criteria in accordance with the BECx plan. The BECx specification should outline the testing and inspection scopes and the roles and responsibilities of the BECx team during the construction phase; and the project close-out and occupancy phase documentation and training requirements. Commissioning activities required of the contractor are included in the BECx specification and should be referenced in the technical specification sections.

7.4.6.2 The BECx specification should include a project-specific matrix that summarizes the type of testing, who is to perform, the timeframe within the project schedule when testing will be performed, the criteria for acceptance (by