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Performance of buildings — Building enclosure thermal performance verification and commissioning —

Part 1: General requirements

Performance des bâtiments — Vérification de la performance thermique de l'enveloppe des bâtiments et mise en service —

Partie 1: Exigences generales

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 3, *Thermal insulation products*.

A list of all parts in the ISO 21105 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is intended to provide a performance verification process to achieve a durable building enclosure that performs in accordance with the contract documents and owner's project requirements. The process described in this document will assist in developing the building owner's project requirements, defining system performance and acceptance attributes, design and construction activities and verifying the installed performance. This process forms the basis for the occupancy and maintenance guide to enable future users and maintenance personnel to maintain the building enclosure, in addition to considering future modifications to the building enclosure.

The commissioning process is developed on behalf of the owner. The process facilitates the owner's transfer of their expectations for the building to the design and construction team. The process is founded in collaboration among all parties comprising the commissioning team. The commissioning process is the most successful when the owner takes an active role in the process. This document engages the owner in commissioning by defining the tasks associated with the process that specifically serve their needs and add value to the project.

In addition to this document, the following documents are planned to be developed in the future:

ISO 21105-2, *Performance of buildings — Building enclosure thermal performance verification and commissioning — Part 2: Foundation: Waterproofing, Vapour Barrier and Insulation*

ISO 21105-3, *Performance of buildings — Building enclosure thermal performance verification and commissioning — Part 3: Above Grade Opaque Wall Areas*

ISO 21105-4, *Performance of buildings — Building enclosure thermal performance verification and commissioning — Part 4: Fenestration*

ISO 21105-5, *Performance of buildings — Building enclosure thermal performance verification and commissioning — Part 5: Horizontal Waterproofing*

ISO 21105-6, *Performance of buildings — Building enclosure thermal performance verification and commissioning — Part 6: Roofing (steep slope roofs, low slope roofs, vegetated), including insulation and vapour barrier (as required), HVAC equipment enclosures, roof curbs, elevator penthouses, etc.*

ISO 21105-7, *Performance of buildings — Building enclosure thermal performance verification and commissioning — Part 7: Sloped Glazing, (skylight, canopy, etc)*

ISO 21105-8, *Performance of buildings — Building enclosure thermal performance verification and commissioning — Part 8: Interior Partitions providing environmental air barrier separation (such as infection control rooms, laboratories, etc.)*

ISO 21105-9, *Performance of buildings — Building enclosure thermal performance verification and commissioning — Part 9: stairwells, elevator chases, mechanical pipe chases that penetrate the enclosure, overhead doors/ rolling doors and contiguous interior space providing environmental air barrier separation (such as vestibules, loading docks, etc.)*

ISO 21105-10, *Performance of buildings — Building enclosure thermal performance verification and commissioning — Part 10: Whole building enclosure, including below grade areas, waterproofing, facades and roof(s). All of the above as applicable*

ISO 21105-11, *Performance of buildings — Building enclosure thermal performance verification and commissioning — Part 11: Re-commissioning and retro-commissioning of existing building enclosures*

ISO 21105-12, *Performance of buildings — Building enclosure thermal performance verification and commissioning — Part 12: Personnel Qualifications and Training*

Performance of buildings — Building enclosure thermal performance verification and commissioning —

Part 1: General requirements

1 Scope

This document describes a building enclosure commissioning process to achieve a well performing, durable and maintainable building enclosure. This document includes procedures, methods and documentation requirements describing the application of the commissioning process to a building enclosure at each phase of a project. These project phases span from predesign through owner occupancy and operation. This process is referred to throughout this document as building enclosure commissioning (BECx).

This document applies to new building construction and building re-commissioning. This document is for use by an owner, commissioning provider, building developer, owner's representative, construction manager, architect, contractor, and/or consultant, etc. Its purpose is to determine and complete the required tasks and activities to deliver a building enclosure which meets the performance requirements of the owner. Requirements for the project are established by the owner and/or commissioning provider (CxP).

This document identifies steps necessary to perform a building enclosure risk analysis. The analysis will result in tasks that define the level of BECx, commensurate with the owner's tolerance for risk associated with building enclosure performance.

The BECx process covered by this document is applicable to an individual assembly, a combination of assemblies or a whole enclosure assembly. For example, an individual assembly can be the fenestration, the air barrier or the thermal insulation. A combination of assemblies would include the fenestration, the air barrier and the complete heat transfer system, (e.g. both the insulation and roof assembly). A whole building enclosure assembly would include all heat, air and moisture control layers of the building enclosure, on all six sides of the building.

This document describes requirements for any third-party consultants and/or building enclosure commissioning providers (BECxP) to document their technical qualifications, independence and knowledge of the BECx process, including their education, training, and experience.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 17024, *Conformity assessment — General requirements for bodies operating certification of persons*

3 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
architect of record
AoR
design *party* (3.17) having responsibility for the project design and *contract documents* (3.13)

3.2
basis of design
BOD
documents recording narratives, lists, calculations, technical concepts, performance parameters, assumptions, decisions, product selections, etc. that bridge the objectives conveyed in the *owner's project requirements* (3.16) and the *contract documents* (3.13)

3.3
building enclosure assembly
single assembly which comprises one portion of the overall building enclosure system design

3.4
building enclosure commissioning provider
BECxP
party (3.17) retained by the owner or *CxP* (3.9) their agent who has demonstrated the knowledge, education and experience in the technical capabilities required to perform the tasks described by the program

3.5
building enclosure commissioning
BECx
process of enhancing the delivery of the design and construction of a building enclosure by verifying and documenting the building enclosure concepts, designs, materials, components, assemblies and systems that have been designed, installed and performance tested, and are maintainable, in accordance with the *OPR* (3.16)

3.6
building enclosure commissioning specification
contract document (3.13) developed during the design of the *commissioning* (3.7) phase and included in the project manual detailing the, scope, acceptance and implementation of the commissioning process

3.7
commissioning
Cx
quality-centred process for enhancing the delivery of a project by verifying and documenting that all systems and assemblies are planned, designed, reviewed, installed, tested, operated and maintained to meet the *OPR* (3.16)

3.8
commissioning plan
BECx plan
document that describes the organization, schedule, allocation of resources, and documentation requirements of *commissioning* (3.7)

3.9
commissioning provider
CxP
commissioning authority
commissioning agent
CxA
party (3.17) retained by the owner who leads, plans, schedules and coordinates the *commissioning team* (3.11) to implement the *commissioning* (3.7) process

3.10
commissioning report
final deliverable in the commissioning process which provides the information needed to understand, operate and maintain the facility and its assemblies

3.11
commissioning team
parties (3.17) including the owner, *CxP* (3.9), *BECxP* (3.4), *AoR* (3.1), contractor, sub-contractor and testing agency necessary to complete the *building enclosure commissioning* (3.5)

3.12
construction observation
site visits performed by the *BECxP* (3.4) at intervals to coincide with significant construction detail installations and the schedule

3.13
contract documents
CDs
set of drawings and specifications (project manual), which form the basis for the construction contract and articulates the *OPR* (3.16), and overall design that is provided by the *AoR* (3.1) of the project

3.14
design review
examination of the drawings and specifications for compliance with the *OPR* (3.16)

3.15
field testing
on-site testing of building enclosure materials, components, assemblies and systems, conducted by an authorized manufacturer's technical representative, contractor, independent testing agency and/or *BECxP* (3.4)

3.16
owner's project requirements
OPR
written document that details the ideas, concepts and criteria required by the owner, and the requirements upon which the predesign, design and construction phases are based

3.17
party
entity legally responsible for a portion of the work

3.18
re-commissioning
commissioning (3.7) applied to a previously commissioned building enclosure to verify that the building enclosure has maintained compliance with the *OPR* (3.16)

3.19
substantial completion
phase defined in the owner-contractor agreement, close to the end of the construction period

4 Commissioning process

The BECx process commences with the predesign phase, followed by the design phase, the construction phase and concludes with the occupancy/maintenance/operation phase. If defined by the owner, the BECx process will extend into the occupancy phase of the building.

This document establishes the activities and tasks to be performed by the commissioning team by first undertaking a risk analysis. The analysis includes such factors as the building environment and the complexity of the design of the enclosure to identify a level of commissioning and specific tasks in the BECx process to achieve the building enclosure performance goals and OPR. The owner, CxP and/or

BECxP shall compile and document the risk analysis, budget and guide the BECx process and tasks. Once determined by the risk analysis, the scope of work shall specify the required tasks associated with a particular tolerance of risk for the building type or use, and define the BECx process.

The BECx process is completed by a BECxP who is qualified to perform the building enclosure (BE) assembly or system commissioning. The BECxP is part of the overall Cx team, under direction of the CxP for the project. The owner or the CxP shall hold the contract for the BECxP. Procurement/tender of the BECxP is via request for qualifications. The proposing BECxP shall provide documented experience of building enclosure commissioning via previous project case histories/studies, personnel resumes that are intended to be assigned to the project, and demonstration of the technical capabilities required to evaluate and verify the BE assemblies to be commissioned. This assures that the BECx process provides added value to the owner. At the time of request for qualifications, a budget estimate shall be provided by the proposing BECxP.

An overview of the procedures, methods and documentation requirements for each task or activity from predesign through occupancy and operation are included in Clause 7. The minimum scope of work, minimum documentation requirements and acceptance requirements for each task are to be developed by this Cx team describing the BECx program for each type of building enclosure assembly.

The BECx program follows the process described below:

— The owner and CxP begin the process by defining an overall acceptable level of risk for the building enclosure assemblies.

— The minimum tasks or activities that are to be performed at each phase of the project design and the construction delivery are defined. This is known as a level of BECx.

— To enhance the minimum task list and scope of work, the owner and CxP shall increase the frequency of repeating specific tasks during a phase. However, to achieve the specific level of commissioning, each task shall be performed as stipulated by the owner and CxP at the selected level of the BECx program.

— The owner and CxP determine the building enclosure assemblies to be commissioned. The building enclosure assemblies include one or more of the following:

  — Foundation: waterproofing, vapour barrier and insulation;

  — Above grade opaque wall areas: air/moisture barrier, heat transfer control/continuity, including all types of insulation;

  — Fenestration: glazed curtain wall, window wall, storefront, windows and doors, etc.;

  — Horizontal waterproofing: balcony, plaza, etc.

  — Roofing: steep slope roofs, low slope roofs, vegetated, including insulation and vapour barrier (as required), HVAC equipment enclosures, roof curbs, elevator penthouses, etc., sloped glazing, (skylight, canopy, etc.);

  — Interior partitions providing environmental air barrier separation, such as infection control rooms, laboratories, etc.;

  — Stairwells, elevator chases, mechanical pipe chases that penetrate the enclosure, overhead doors/ rolling doors and contiguous interior space providing environmental air barrier separation (such as vestibules, loading docks, etc.);

  — Whole building enclosure, including below grade areas, waterproofing, facades and roof(s).

— The owner and CxP assemble the commissioning team to perform the tasks for the level of BECx and the assemblies to be commissioned.

5 Risk assessment to determine the level of BECx

The owner and the CxP shall first determine the BECx level and BECx tasks to be completed for the Cx program. Levels of BECx are:

Level 1: Basic - minimum

Level 2: Intermediate - medium

Level 3: Comprehensive - maximum

Annex A contains information related to determining a level of quality assurance and commissioning based upon each of the following risk factors:

a) owner risk tolerance;

b) cost of loss per square meter of area repaired;

c) building use or function (including potential future use);

d) area of building enclosure;

e) building enclosure design complexity;

f) environment;

g) level of innovation and/or performance, and/or building sustainability;

h) owner's number of prior projects and bidding requirements;

i) level of commitment of the owner's representatives to the project throughout all phases;

j) schedule;

k) project delivery method;

l) experience and knowledge of contractor.

Using Table 1, the owner and CxP shall determine the level of BECx program required based upon the risk assessment. Table 1 applies to commercial buildings:

Table 1 — Risk assessment criteria

	Level of BECx	**Value of points:**	**1 Point**		**2 Points**		**3 Points**
To calculate the score: Assign a point score (1, 2 or 3) adjacent to only one of the risk factor criteria:							
	Risk factors[a]						
A	Owner risk tolerance	High tolerance		Medium tolerance		Low tolerance	
B	Cost of loss per square meter of area repaired	Low cost		Medium cost		High cost	
C	Area of building enclosure - m^2	Less than or equal to 5,000 m^2		Less than or equal to 15,000 m^2		Greater than 15,000 m^2	
D	Building enclosure design complexity	Basic		Custom		Complex, custom design	
E	Environment	Low exposure		Medium exposure		High exposure	
[a] If the risk assessment criteria is not applicable to the specific project, the points should be zero.							

Table 1 *(continued)*

	Level of BECx	Value of points:	1 Point		2 Points		3 Points
F	Level of innovation and/or performance and/or building sustainability	Basic		Enhanced		Experimental	
G	Owner's number of prior projects and bidding requirements	10 or more / choice of bidders		3 to 10 / some bid acceptance restrictions		Less than 3 / required to take low bidder	
H	Level of commitment of the owner's representatives to the project throughout all phases	Significant involvement in project		Sporadic involvement in project		Little involvement in project	
I	Schedule	Basic schedule		Lean or just-in-time		Fast track	
J	Project delivery method	Traditional or integrated project delivery		Contract manager at risk		Design/build or cost plus	
K	Experience and knowledge of contractor	10 or more of same size and complexity. Trained and fulfilling the requirements of ISO 17024		3 to 10 buildings of same size and complexity		Less than 3 buildings of same size and complexity	
	Total points: Columns A+B+C = _____	A	_____	B	_____	C	_____
[a]	If the risk assessment criteria is not applicable to the specific project, the points should be zero.						

Table 2 — Points and recommended level of BECx

Total points:	Level of BECx
1-15	1 - Basic
12-24	2 - Intermediate
21-33	3 - Comprehensive

Per Table 2, where there is an overlap in point ratings between levels, the owner shall choose the most appropriate level of the BECx program to suit their specific goals and acceptance of risk.

The level of BECx required by the owner shall be confirmed with the BECxP. If the level of commissioning is changed, the owner shall document this decision and inform the BECxP.

The owner and CxP shall confirm the building enclosure assemblies to be commissioned. Differing levels of BECx may be performed on each assembly. The building enclosure assemblies subject to commissioning may include one or more of the following:

— Foundation: waterproofing, vapour barrier and insulation;

— Above grade opaque wall areas: air/moisture barrier, heat transfer control/continuity, including all types of insulation;

— Fenestration: glazed curtain wall, window wall, storefront, windows and doors, etc.;

— Horizontal waterproofing: balcony, plaza, etc.;

— Roofing: steep slope roofs, low slope roofs, vegetated, including insulation and vapour barrier (as required), HVAC equipment enclosures, roof curbs, elevator penthouses, etc., sloped glazing, (skylight, canopy, etc.);

— Interior partitions providing environmental air barrier separation, such as infection control rooms, laboratories, etc.;

— Stairwells, elevator chases, mechanical pipe chases that penetrate the enclosure, overhead doors/rolling doors and contiguous interior space providing environmental air barrier separation (such as vestibules, loading docks, etc.);

— Whole building enclosure, including below grade areas, waterproofing, facades and roof(s).

6 Levels of BECx program

Each level has many fundamental tasks that are required to achieve the process. From these fundamental tasks, such as development of the building enclosure's OPR, the tasks increase in complexity and number corresponding with the enhanced level of BECx.

Level 1 basic BECx would require only one design review, monthly construction observation site visits, and witness to 25 % of performance testing during construction. By contrast, level 3 comprehensive BECx would require three design reviews, weekly construction observation site visits, and witness to 100 % of performance testing during construction. The tasks associated with each of the levels vary in accordance with the owner's tolerance of risk.

Table 3 describes phases of a project and the tasks associated with each level as required by this document. The BECxP shall confirm with the owner and/or CxP that the extent of tasks is appropriate, relative to the initial risk assessment, and shall provide documentation of these tasks in the commissioning plan to achieve the OPR.

Different methods to engage the CxP are recommended for each of the levels:

Level 1: The BECxP shall be a party employed by the owner or CxP, design or construction parties, with sufficient independence and knowledge to implement the process and provide technical expertise to the project. The BECxP shall act independent of the design and construction teams and report directly to the owner and CxP on all matters.

Levels 2 and 3: The BECxP is independent of the design and construction entities and is contracted directly to the owner or CxP.

Table 3 — Tasks required by each level of BECx by phase

BECx phase	BECx task	Level of BECx: 3	2	1
PREDESIGN	Determine BECx level & systems to be commissioned	√	√	√
	Owner project requirements (OPR-BE)	√	√	√
	BECx plan	√	√	X
	Review architects basis of design	√	√	X
DESIGN	BECx design review #1 and meeting	√	√	√
	BECx design review #2 and meeting	√	√	X
	BECx design review #3 and meeting	√	X	X
	BECx specification	√	√	√
CONSTRUCTION	Bid scope & pricing review	√	X	X
	BECx introductory meeting	√	√	X
	BECx submittal review	√	√	X
	Attend preconstruction trade meetings	√	X	X
	Checklists	√	√	√
	Review schedule	√	X	X
	Construction observation - weekly	√	X	X
	Construction observation - bi-weekly	√	√	X
	Construction observation - monthly	√	X	√
	BECx meetings during construction	√	X	X
	Witness testing - 100%	√	X	X
	Witness testing - 50%	√	√	X
	Witness testing - 25%	√	X	√
	BECx report	√	√	√
OCCUPANCY	BE systems maintenance manual	√	X	X
	Facility staff training	√	X	X
	10 month prewarranty review	√	√	X
	BE monitoring / on-going BECx plan	√	√	X
	CFR plan	√	X	X
	Final BECx report	√	X	X

7 Phases of BECx program

7.1 General

The tasks described below shall be performed for the various levels of BECx, in accordance with Table 3.

7.2 Predesign phase

7.2.1 General

Predesign is a preparatory phase of the project commissioning process that establishes the OPR and the scope of commissioning for all future phases of the project.

7.2.2 Predesign scope of work

Predesign is a preparatory phase of the project delivery process in which the owner is responsible for identifying the:

a) risk to determine level of BECx;

b) building enclosure assemblies to be commissioned;

c) Cx and BECx team;

d) BECx tasks;

e) OPR;

f) budget for the BECx program;

g) general information about the overall project;

h) BECx plan;

i) BECx progress report.

7.2.3 BECx project team

7.2.3.1 The owner shall establish a project commissioning team that shall implement the BECx process required by this document.

7.2.3.2 During the predesign phase, the owner shall specify the BECx team's responsibilities to include:

a) developing the OPR that includes the building enclosure goals and objectives;

b) establishing protocols for:

- documentation and communication protocols;
- format for the building enclosure maintenance and inspection manual;
- format for the BECx final report;
- establishment of the BECx plan, scope and budget;

c) verifying the roles and responsibilities for each member of the team; understand the nature of the commissioning tasks and how they will impact each independent team member or trade's scope of work;

d) identification of BECx tasks to be included in the project schedule.

7.2.3.3 The owner shall designate a CxP to supervise the overall commissioning process and a BECxP for building enclosure performance verification and commissioning program responsibilities.

7.2.4 Owner's project requirements - building enclosure

7.2.4.1 The owner shall make every effort to ensure the development of the OPR is established prior to development of the architectural program or basis of design (BOD). If the OPR is not developed ahead of the BOD, the owner shall ensure that the documents are coordinated and that the architect is aware of the requirements specified by the OPR prior to design development.

7.2.4.2 The owner shall identify the extent to which the OPR provides:

a) the basic requirements from which design, construction, acceptance and maintenance decisions are made;

b) information to assist the project team plan, design, construct and maintain a durable building enclosure;

c) the building enclosure performance expectations specified during the development process of the OPR.

7.2.4.3 The owner shall specify the extent to which the predesign phase OPR document includes:

a) the project definition including function, project schedule and budget;

b) a vision for the building enclosure, including such items as:

- owner directives, restrictions or limitations;
- durability expectations and resilience;
- building enclosure life expectancy;
- increased performance related to energy efficiency and sustainability;
- community requirements;
- ability to adapt to future expansion;
- integration of assemblies;
- indoor environmental requirements;
- acoustics, resilience, controls, security or communications;
- user requirements;
- building safety and maintenance access requirements;
- occupant schedules;
- training of facility engineering;
- "lessons learned" from previous projects.

7.2.4.4 The owner shall require that:

a) if the OPR evolves throughout the project, all changes are documented;

b) the OPR is used for benchmarking performance metrics and decision-making during all phases of the project;

c) a final updated and approved OPR is provided at substantial completion.

7.2.5 BECx introductory meeting

The owner shall specify that commissioning activities in the predesign phase begin with an introductory meeting and that the agenda of this meeting includes identification of project objectives and discussion of the project's commissioning process. The owner shall also specify the extent to which the agenda also includes:

a) an introduction to the BECx process, including the various tasks and objectives of each phase;

b) the project delivery method and the extent to which the various building assemblies will be commissioned; coordination with other systems to be commissioned shall be addressed;

c) design objectives including the owner's approach to energy usage, facility life cycle requirements and code requirements.

7.2.6 BECx budget

The owner and CxP shall direct the BECx team to develop preliminary estimates of a BECx budget developed early on during the predesign phase and include preliminary estimates of the costs to accomplish the BECx activities including but not limited to those listed in 7.2.7.

7.2.7 BECx tasks

The owner and CxP shall define the tasks of the commissioning BECx program as determined by the level of commissioning during building design, construction and occupancy, including, but not limited to:

a) Predesign phase:

- determine BECx level and assemblies to be commissioned;
- review the owner's project requirements for the building enclosure (OPR-BE);
- develop the building enclosure performance verification and commissioning plan;
- review architect's basis of design.

b) Design phase:

- BECx design review and meeting;
- BECx specification.

c) Construction phase:

- review of scope of work subcontractor bid packages and bids;
- BECx introductory meeting;
- BECx submittal review;
- attendance at trade pre-construction meetings;
- BECx checklists;
- review of building enclosure schedule;
- construction observation;
- BECx meetings and documentation of observations and issues, via an issues log;
- witness testing of laboratory mock-up or field mock-up;
- witness field performance verification testing of building enclosure materials, components, assemblies and systems during initial installation and at various stages throughout construction;
- BECx report.

d) Occupancy and maintenance phase:

- BE assembly maintenance manual;
- facility engineer training;

— 10-month warranty BE review;

— BE monitoring/on-going commissioning plan.

— continuing facility requirements;

— final BECx report.

7.2.8 BECx plan

The owner and/or CxP shall direct the BECx team to develop a commissioning plan that:

a) identifies the BECx processes and procedures necessary to achieve the contract documents;

b) responds to the individual project specific requirements, geometry, environment, interior conditions, function and owner requirements, etc.;

c) takes into account the owner's risk management strategy and overall complexity of the building enclosure design and performance requirements;

d) identifies the roles and responsibilities of the BECx team.

7.2.9 Basis of design review

The owner and/or CxP shall direct the BECxP to perform a review of the AoR's BOD document. The review shall verify that the BOD is coordinated with the OPR and will achieve the objectives of the owner specified by the OPR.

7.2.10 BECx progress report

The owner and/or CxP shall direct the BECx team to develop a summary report that:

a) specifies BECx process tasks encompassed by predesign;

b) documents the predesign process and work result;

c) is included in the final BECx report.

7.3 Design phase

7.3.1 General

The design phase comprises tasks to accomplish and verify the owner's project requirements are comprehensively specified and detailed in the contract documents (CDs). Design reviews shall be performed and documented by the BECxP. Team meetings shall be held to review and discuss the performance requirements of building enclosure assemblies for compliance with the OPR.

The BECx plan shall be refined and BECx project-specific specifications included in the project manual.

7.3.2 Design phase meeting

The phase shall begin with a meeting of the Cx team to discuss the OPR and design goals for the project. The agenda shall include:

— objectives for commissioning of the building enclosure;

— AoR description of the design phase process and deliverables for the schematic design, design development and contract document stages;

— schedule for design reviews to be performed by the BECxP;

— AoR response to BECxP design review comments;

— communication protocols between the BECx team.

7.3.3 Level 1 (basic) BECx design review

7.3.3.1 Design documents review

Perform a minimum of one technical design review, and one final objectives (back-check) review at the end of the design phase of the building enclosure assemblies to be commissioned, including the alternative schemes for appropriateness and impact on the OPR at an interval during the design phase appropriate for the complexity of the project. The review shall include the following:

— performance criteria for the building enclosure and assemblies to be commissioned; a determination and hierarchical analysis of the performance and aesthetic parameters should be compiled to balance objectives in the OPR and provide maximum value to the owner;

— comparison of the building enclosure assembly's criteria with other systems and other project criteria including the functional program, budget, aesthetics and performance;

— technical evaluation of the assembly(s) design solution(s) and the impact and relationship with inter-dependent systems;

— comparison of building enclosure assemblies and typical details for system interfacing continuity, durability and long-term service; review and evaluate both the constructability and the design continuity for system control layer(s) at all interfacing details;

— recommendation(s) for the development of additional details and drawings;

— specifications review for assembly(s), sufficiency and coordination with the drawings; specifications review for inclusion of commissioning process requirements, including submittal requirements, training requirements, testing requirements, inspection requirements, mock-ups, performance requirements, CM's/contractor's quality assurance requirements, etc.;

— required performance testing of assembly(s);

— verification of compliance of the contract documents against the OPR.

7.3.3.2 Design review report(s)

The design review report shall advise the project team on technical matters, provide recommendations for the development of details, including components, accessories and assemblies, and review documents for completion and coordination.

a) BECxP shall provide design review report following the review of the drawings and specifications;

b) BECxP shall perform an objectives review (back-check) at the end of the design phase to address whether the objectives for the OPR have been met by the design. Unresolved issues should be documented, and the resulting issues log shall be reviewed by the owner for resolution.

7.3.3.3 Design review meeting(s)

Meeting(s) to review the design review report shall be conducted shortly after the completion of the review, allowing the AoR to fully review the report and establish responses to each of the items identified in the report. A design review meeting shall follow each design review report.

7.3.4 Level 2 (intermediate) BECx design review

7.3.4.1 Design documents review

Perform a minimum of two technical design reviews and one final objectives review at the end of the design phase of the building enclosure assemblies to be commissioned, including any alternative schemes for appropriateness and impact on the OPR at an interval during the design phase appropriate for the complexity of the project. The reviews shall include the following:

— performance criteria for the building enclosure and assemblies to be commissioned; a determination and hierarchical analysis of the performance and aesthetic parameters should be compiled to balance objectives in the OPR and provide maximum value to the owner;

— comparison of the building enclosure assembly's criteria with other assemblies and other project criteria including the functional program, budget, aesthetics and performance;

— technical evaluation of the assembly design solution(s) and the impact and relationship with inter-dependent systems;

— comparison of building enclosure assemblies, and typical details for system interfacing continuity; review and evaluate both the constructability and the design continuity for assembly control layer(s) at all interfacing details;

— recommendation(s) for the development of additional details and drawings; revision of the entire set of contract documents for completeness and coordination, including but not limited to structural, mechanical, electrical and plumbing drawings as they impact or are pertinent to the building enclosure;

— specifications review for assemblies, sufficiency and coordination with the drawings; revision of the specifications for inclusion of commissioning process requirements, including submittal requirements, training requirements, testing requirements, inspection requirements, mock-ups, performance requirements, CM's/contractor's quality assurance requirements, etc.;

— revision and provision of advice on laboratory and field mock-ups, testing and inspection procedures;

— required performance testing of assembly(s);

— verification of compliance of the contract documents against the OPR.

7.3.4.2 Design review report(s)

The design review report shall advise the project team on technical matters, provide recommendations for the development of details, systems and assemblies, and review documents for completion and coordination.

a) BECxP shall provide design review reports following the review of the drawings and specifications;

b) BECxP shall perform an objectives review (back-check) at the end of the design phase to address whether the objectives for the OPR have been met by the design. Unresolved issues should be documented and the resulting issues log shall be reviewed by the owner for resolution.

7.3.4.3 Design review meeting(s)

Meeting(s) to review the design review report shall be conducted shortly after the completion of the review, allowing the AoR to fully review the report and establish responses to each of the items identified in the report. A design review meeting shall follow each design review report.

7.3.5 Level 3 (comprehensive) BECx design review

7.3.5.1 Design documents review

Perform a minimum of three technical design reviews and one final objectives review at the end of the design phase of the building enclosure assembly(s) to be commissioned, including any alternative schemes for appropriateness and impact on the OPR at the schematic design, design development and 50 % contract document (or as appropriate to design packages) phases of the project. The review shall include the following:

— performance criteria for the building enclosure and assembly(s) to be commissioned; a determination and hierarchical analysis of the performance and aesthetic parameters should be compiled to balance objectives in the OPR and provide maximum value to the owner;

— comparison of the building enclosure assembly's criteria with other assemblies and other project criteria including the functional program, budget, aesthetics and performance;

— technical evaluation of the assemblies' design solution(s) and the impact and relationship with inter-dependent assemblies;

— comparison of building enclosure assemblies and typical details for assembly interfacing continuity; revision and evaluation of both constructability and the design continuity for assembly control layer(s) at all interfacing details;

— review and evaluation of both the constructability and the design continuity for assemblies and control layer(s) interfacing details;

— details to be reviewed should include, but not limited to: typical details for roof to wall, foundation-to-wall, fenestration, wall to floor, wall to column, wall to floor, penetrations and other features which are common or highly repeated for the various enclosure assembly layering options;

— recommendations to the project team on technical matters for the development of details, systems and assemblies, and review the contract documents for completion and coordination;

— recommendation(s) for the development of additional details and drawings; review of the entire set of CD documents for completeness and coordination, including but not limited to structural, mechanical, electrical and plumbing drawings as they impact or are pertinent to the building enclosure;

— specifications review for assembly(s), sufficiency and coordination with the drawings; review specifications for inclusion of commissioning process requirements, including submittal requirements, training requirements, testing requirements, inspection requirements, mock-ups, performance requirements, CM's/contractor's quality assurance requirements, etc.;

— revision and provision of advice on laboratory and field mock-ups, testing and inspection procedures;

— required performance testing of assemblies;

— revision and provision of advice regarding the heat/air/moisture performance of details; back-check and provide review of numerical thermal analysis by the A/E team, if necessary;

— verification of the contract documents against the OPR; review the ability of each enclosure assembly to be commissioned for the capability of that assembly to satisfy the OPR and for the appropriateness of use of that assembly within the overall design.

7.3.5.2 Design review report(s)

The design review report should advise the project team on technical matters, provide recommendations for the development of details, systems and assemblies, and review documents for completion and coordination.

a) BECxP shall provide design review reports following the review of the drawings and specifications;

b) BECxP shall perform an objectives review (back-check) at the end of the design phase to address whether the objectives for the OPR have been met by the design. Unresolved issues should be documented, and the resulting issues log shall be reviewed by the owner for resolution.

7.3.5.3 Design review meeting(s)

Meeting(s) to review the design review report shall be conducted shortly after the completion of the review, allowing the AoR to fully review the report and establish responses to each of the items identified in the report. A design review meeting shall follow each design review report. Meet with the project team periodically during the contract document phase at intervals appropriate for the complexity of the project and the expertise of the project team.

7.3.6 BECx specification

A specification for the commissioning of the building enclosure assemblies shall be produced for inclusion in the project manual. Commissioning activities required of the AoR and contractor are included in the specification. The BECx section shall include, at minimum, the follow information:

— project-specific building enclosure commissioning specification;

— a list of assemblies to be commissioned and level of commissioning per the BECx standard;

— a definition of the roles and responsibilities of the construction-phase commissioning team;

— project-specific matrix that clearly summarizes per assembly, the type of testing, who is to perform, when will testing be performed, what is the criteria for acceptance, how is the testing to be documented, who will receive the documentation of these inspections, additional tests in the event of failure, and who is responsible for the cost of re-testing in the event of failure;

— a preliminary schedule of building-enclosure-related commissioning process activities for (a) the construction phase and (b) the occupancy and operations phase; the schedule shall identify critical times for witnessing testing activities, building enclosure assemblies and activities relative to substantial completion/project closeout;

— in developing the test procedures, special attention shall be paid to issues of personnel safety, equipment/assembly protection, access and the site's ability to provide water, electricity, etc. to successfully perform the tests.

7.3.7 OPR and Cx plan updates

Updates to the OPR and Cx plan shall be performed as required at the completion of the design phase by the BECxP. The OPR shall be provided to the owner for review and approval prior to proceeding with the construction phase. The Cx plan shall be updated by the BECxP and provided to the Cx team for review.

7.4 Construction phase

7.4.1 General

The construction phase of the process typically introduces the actual materials and methods of construction to the project. At this phase, the BECxP introduces the BECx process, reviews submittals, observes construction, reviews field performance testing and generates reports documenting the activities occurring in the field. The initial risk assessment assumed an experience and knowledge of

contractor based upon the number of similar buildings constructed. If the implementation of the work exceeds or fails to perform to the initial contractor assessment, then modifications to the BECxP are required during construction. The BECxP is responsible to raise this issue with the owner and CxP for appropriate action.

7.4.2 Construction phase documentation requirements

Documentation of the building enclosure for all levels of BECx is to include action item logs, including resolution and unresolved items, testing results and areas where testing was performed, checklists, remediation of problems encountered during construction and verification of as-built documents, final BECx plan, final OPR and building enclosure maintenance manual.

7.4.3 Level 3 (comprehensive) review of bid documents

This task shall be completed for level 3 BECx, and includes the BECxP review and comment to the owner of accuracy and compliance of the scope of work bid packages and bids, with the CDs and OPR.

7.4.4 Construction phase introductory meeting

This phase shall begin with a construction phase BECx meeting to define the objectives of the BECx process, as well as the team member roles and responsibilities. Agenda items shall include, but are not limited to, BECx specification, submittals, mock up(s), construction sequencing, constructability, BECx documentation process, field observations, field performance testing activities including repair and retesting, project schedule, issues log, job site safety and other issues pertaining to the project coordination, verification and construction of the building enclosure assembly.

7.4.5 Checklists

The development of checklists is a requirement of the program. Project-specific checklists shall be developed that are related to the installation of materials, components and assemblies that are to be commissioned and comprise the building enclosure. Checklists shall be developed by the BECxP, with input from the contractor. Use a checklist to verify that the installation complies with the contract documents.

7.4.6 Building enclosure maintenance manual

A building enclosure assembly maintenance manual shall be compiled for level 3 BECx program only and is to incorporate information generated during the construction phase. The manual should include an overview of all enclosure types and assemblies, and the purpose and general overview of each enclosure type and location installed, in addition to the maintenance and inspection schedule. The general description section should meet the knowledge needs of the engineering and maintenance staff, occupants, and owners. In addition, add the following items to the manual:

a) maintenance requirements – periodic inspection of the building enclosure;

b) replacement schedule – based upon the service life of the building enclosure and the individual materials, accessories and assemblies.

7.4.7 Construction phase BECx program tasks

7.4.7.1 General

The extent to which these tasks are implemented shall depend upon the level of commissioning and the number of assemblies to be commissioned.

7.4.7.2 Submittal review(s)

Perform technical reviews of the building enclosure assembly submittals, assist in the evaluation of substitution requests and provide documentation.

Review the building enclosure shop drawings and product data in direct reference to the contract documents and the OPR. Evaluate issues that can impact the constructability, function, durability of the individual assemblies, installation instructions from the manufacturer, maintenance and replacement, including but not limited to:

— review of the interface conditions, tolerances, sequence of installation, material compatibility;

— integration and coordination of shop drawings for interfacing materials and assemblies;

— compatibility and adhesion to adjacent building enclosure assemblies; evaluate that the durability meets intended life of building enclosure assembly or that the product can be removed and replaced as part of scheduled maintenance during the service life of the specific building enclosure assembly.

7.4.7.3 Preconstruction trade meeting(s)

Attend the preconstruction meeting(s) held for each building enclosure assembly to be commissioned. Agenda items include the specific observations, performance tests and documentation to be conducted on the assemblies, scheduling and sequencing, review of check lists, review of the contractor site specific quality plan, review of non-conformances/issues log/inspections, testing and documentation protocols and, finalization of construction checklists.

7.4.7.4 Schedule review

Review the project schedule for inclusion of BECx activities, including but not limited to schedule of submittals, laboratory testing, sample construction, mock up testing, field performance testing (possible repairs) and inspection by the jurisdiction having authority or code authority. A schedule review shall be performed for level 3 only.

7.4.7.5 Construction observation

Perform periodic construction observation review of the contractor's efforts to assure and control workmanship, functional installation, material and assembly performance. Perform construction observations at milestone activities, including but not limited to mock-ups, commencement of new trades, randomly scheduled site review and field testing.

a) Verify mock up construction in the field to demonstrate that workmanship has been completed and that the work in place on the building complies with the manufacturer's installation instructions, design intent and specifications;

b) Perform site visits to verify and document compliance with the contract documents and the owner's project requirements. Coordination of the scheduling of these building enclosure assembly visits should involve the contractors, manufacturers and consultants in relation to the project schedule. Perform site observations to coordinate with specific installation of enclosure details, including field mock-ups, start-up of trades, complex details, field testing and problematic installations;

c) Document site observations, promptly identifying issues or non-compliance issues on the issue log.

7.4.7.6 BECx meetings during construction

Conduct routine meetings during the building enclosure field construction to discuss performance testing, issues log, and testing schedule with associated documentation. Stand-alone BECx meetings shall be conducted for level 3 only. BECx meetings shall occur simultaneously with construction observation site visits for levels 1 and 2.

7.4.7.7 Field verification testing

Witness, coordinate, perform and document field performance testing as defined by the building enclosure commissioning specification and related sections. Interpret test results and recommend additional testing, if deemed necessary due to failure or systemic conditions.

a) Verify field testing, including type, location and frequency as defined by the specification and associated building enclosure sections in the project manual. Protocols to address failures, repeat tests and additional testing as warranted. Show locations of the building enclosure field performance tests on project drawings, specifically on exterior elevations and roof/waterproofing plans;

b) Implement a project-specific plan that includes testing, who is to perform the testing, when testing will occur, criteria for acceptance, how testing will be documented and who will receive the documentation of the testing. In the event that a test fails, define the amount of additional testing required on the assembly and responsibility for cost. Verify the testing plan is included in the contractor's schedule;

c) Verify the test procedures address the various materials, components and assembly(s) that comprise the building enclosure and will achieve the owner's project requirements;

d) Verify the manufacturers performance testing has been performed by an independent third party laboratory meeting the requirements per the contract documents. Verify that the testing agency meets the requirements of the certifying authority;

e) Document testing promptly identifying issues or non-compliance issues on the issue log. Record environmental conditions, e.g. ambient temperature, humidity, time-of-day, barometric pressure, solar conditions, wind, rain at time of testing. Document the test results, including re-verification that the test standards and performance criteria adapted by the testing agency prior to and during testing are consistent with the criteria established in the contract documents for the project, and appropriate for the building enclosure material, component or assembly to be tested. Document whether a test passed or failed, and any remedial action that was completed during the test, and the applicability of said remedial action to similar building enclosure systems or assemblies that will exist at other locations throughout the project. The number of all tests completed is to be noted, together with a list of names and contact information for all witnesses to each test. Provide observation, review and commentary, as appropriate, on:

   — the anticipated long-term durability of all remedial actions taken because of non-conformance testing;

   — the approved submittals made by the parties responsible for non-conformances inclusive of the repair submittal for the non-conformance and field mock-up of trial repairs;

   — whether the said remedial action for each non-conformance has been properly executed on a building-wide basis where applicable.

7.4.7.8 Building enclosure commissioning report

Submit the construction phase BECx report for owner review. Submit the draft report to other commissioning team members for review. Incorporate review comments from all BECx team members, including the owner, into the final construction phase BECx report. Include the following in the report:

— design review(s) and any outstanding issues;

— issue logs, including resolution and unresolved items;

— testing results and areas where testing was performed;

— remediation of problems encountered during construction;

— verification of as-built documents;

— final BECx plan;

— final OPR;

— maintenance manual for level 3.

7.4.7.9 Owner's project requirements and commissioning plan

Update the OPR and BECx plan to reflect activities and decisions made during the construction phase of the project.

a) Update the OPR to reflect modifications to the design accepted by the owner and architect-of-record resulting from the construction phase activities;

b) Update the BECx commissioning plan to reflect modifications resulting from the construction phase activities.

7.5 Occupancy phase

7.5.1 General

This phase addresses the transition from construction of the facility to occupancy and is key to the successful completion of the BECx program.

7.5.2 BE assembly maintenance manual

The BECxP shall develop a maintenance manual on behalf of the owner to address how the assembly(s) that were commissioned on the building enclosure are to be maintained, the estimated service life of assembly(s), associated warranty information and recommended budget for annual maintenance associated with the commissioned assembly(s) of the building enclosure for the initial 20 years of service.

7.5.3 Facility staff training

The BECxP shall perform training on the building enclosure assemblies commissioning during the BECx program. The requirements of the training shall be specified by the OPR. Training shall address the function of the building enclosure assemblies and a plan for a building enclosure preventative maintenance program, including cyclical verification of building enclosure components with enforcement of warranty provisions.

7.5.4 Ten-month warranty review

The BECxP shall perform a pre-expiration of warranty review, at approximately ten months into the service life of the building enclosure. The review shall include the following:

a) The warranty period walk-through inspection for the building enclosure should be scheduled at 10 months and should include representatives from the owner, A/E, facilities management, CM, GC, subcontractors and manufacturers;

b) Provide a written report identifying assembly(s) or items of concern for review by owner, and possible action by contractor.

7.5.5 Building enclosure monitoring/on-going commissioning

BECxP shall develop plan for monitoring or on-going commissioning of the building enclosure assemblies.

7.5.6 Building enclosure continuing facility requirements (CFR)

BECxP shall establish the performance attributes to be achieved for on-going commissioning of the building enclosure assembly(s).

7.5.7 Final (updated) BECx report

At this phase, the BECxP is to verify the accuracy of the documentation records required by the commissioning plan relative to the acceptance of the completed building enclosure including:

— enclosure test records;

— record drawings;

— final commissioning report;

— documentation review and verification of conformance requirements, including owner acceptance of any non-conforming work or exceptions to the OPR;

— building enclosure preventative maintenance program including cyclical verification of building enclosure components with enforcement of warranty provisions;

— additional documentation and verification as specified in the OPR;

— final version of the OPR.