Alberta Infrastructure

Guideline for Building Envelope Commissioning: New Buildings

Introduction

Building envelope failures may arise from inadequacies in the design, construction and operation of buildings and appear to be occurring with increasing frequency in North America. These failures range from minor impacts on building performance such as occupant use and comfort, to significant issues such as life safety risks, code violations, asset deterioration and in some cases result in major issues such as premature deterioration of building materials and damage to structural components. Repair of premature building envelope failure can be expensive and intrusive to existing building occupants. There is increasing awareness of the need for improved quality assurance processes in the design and construction of the building envelope, which is termed "commissioning" for the remainder of this guideline. The intent of commissioning the building envelope is to verify that the delivered building product meets the owner's objectives and expectations as: durable, maintainable, energy efficient and capable of maintaining the desired indoor environments.

The primary goal of implementing a commissioning process for the building envelope system is to confirm that the owner is delivered a building that meets the design intent and performs as expected. Typically, in building construction, commissioning is conducted on mechanical and electrical systems when they are completed and turned over to the owner to ensure proper operational function and to allow for adjustments and optimization of such systems. Building envelope commissioning differs from these other types of commissioning because unlike mechanical and electrical systems, most of the critical building envelope components are covered up by expensive exterior and interior finishes. If commissioning is left to the end of a project, any problems identified will be difficult and expensive to repair. As a result commissioning of the building envelope must be started during the conceptual design process and implemented at various stages throughout the design, construction and operation of a building. A typical building envelope commissioning roadmap is shown on Figure 1. A detailed list of specific building envelope commissioning activities to implement at each step of a building life cycle is given in Table 1.

The purpose of this document is to outline a Building Envelope Commissioning program to support the design and construction of Alberta Infrastructure funded projects. This guideline is for building designers, contractors and consultants. This guide describes what is expected in a building envelope commissioning program, explains what actions are required at specific stages of a building project's life cycle and identifies the parties

to be involved. This guideline is written in the context of projects using a traditional project delivery method of Design-Bid-Build, but can be used with alternative procurement methods such as Design-Build, Construction Management or Design-Build-Finance-Maintain models with some modifications.

Alberta Infrastructure requires all major projects to meet a minimum level of Silver under the LEED Canada Rating System for New Construction. The enhanced commissioning credit (Energy and Atmosphere Credit 3, LEED Canada NC 2009) is expected as mandatory for all projects and commissioning of the building envelope to meet exemplary performance of this credit is encouraged. This guideline may be used to provide direction for project's pursuing this extra credit.

Figure 1. Building Envelope Commissioning Road Map

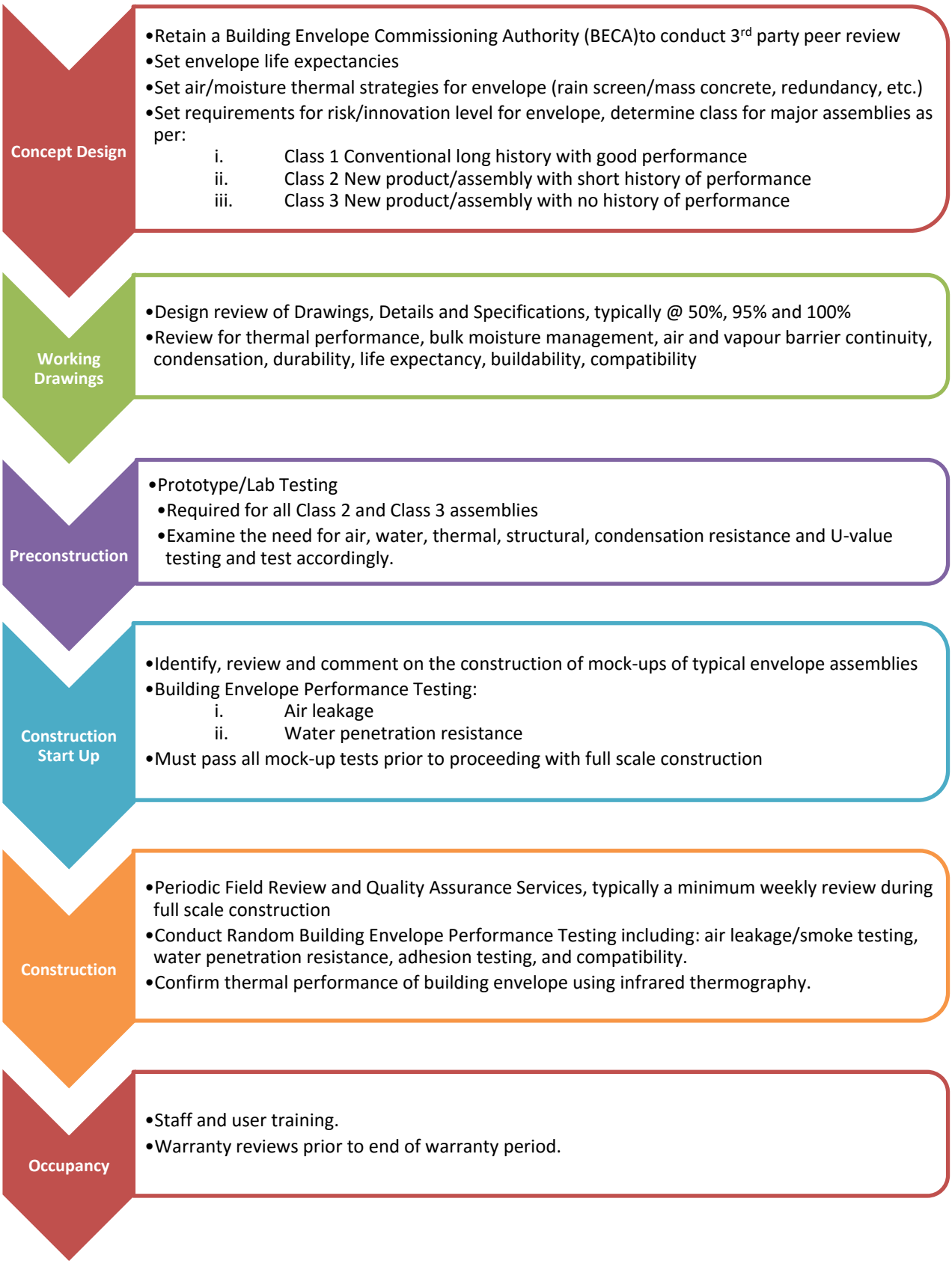

Table 1. Specific Activities of Building Envelope Commissioning Program and Checklist of Involved Parties

	Participant							
Building Project Activity	BECA (Building Envelope Commissioning Authority)	Owner	Architect	Mechanical Engineer	Mechanical Commissioning Agent	General Contractor	Subs	LEED Consultant
A. Preliminary Design Meeting	✓	✓	✓	✓	✓	✓		✓
B. Schematic Design and Coordination	✓*		✓	✓				✓
C. Design Development	✓		✓	✓	✓			✓
D. Construction Document – Peer Review Preliminary Construction Documents (~50%) Final Construction Documents (~95%) Pre-Bid Peer Review	 ✓ ✓ ✓		 ✓ ✓ ✓	 ✓ ✓ ✓	 ✓ ✓ ✓			 ✓ ✓ ✓
E. Value Engineering	✓	✓	✓	✓		✓	?	✓
F. Full Scale Offsite Prototype Testing *	✓	✓	✓			✓	✓	
G. Shop Drawing and Submittals Review	✓		✓	✓		✓		
H. Building Envelope Pre-Construction Coordination Meeting	✓	✓	✓	✓	✓	✓	✓	✓
I. Building Envelope Pre-Installation Meetings with Individual Trades	✓		✓	✓		✓	✓	
J. Mock-ups and Performance Testing	✓	✓	✓			✓	✓	
K. Onsite Construction Field Review and Quality Assurance Services	✓		✓			✓	✓	
L. Project Close Out – Final Walk Through and Deficiency Sign Off	✓	✓	✓			✓		
M. Training on Building Envelope Maintenance	✓	✓						
N. Warranty Review	✓							

**If Warranted by scope and complexity of project.*

Functions of the Building Envelope

Building envelope components comprise a significant portion of a building's systems. Building envelope failures are costly to fix after the construction phase, the purpose of the building envelope commissioning process is to address potential issues as early in the process as possible so that modifications or remedial work can be made cost-effectively. Building envelope failures often occur at interfaces between adjacent assemblies which necessitate greater emphasis on integrating the design, sequencing of trades, and QA/QC (quality assurance/quality control) at these locations.

The building envelope is a system of materials, components, and assemblies that physically separate the exterior environment from the interior environment(s). The typical elements of the building envelope include roofs, above-grade walls, vertical glazing systems, skylights, doors, below-grade walls and the base floor system. These elements are three-dimensional and must perform a variety of functions both as individual elements and together as an integrated system. A summary of building envelope functions is presented below,

- **Control rain penetration, snow and ice**
- **Control ground moisture**
- **Control condensation**
- **Control air flow (including soil gas, radon)**
- **Control water vapour flow**
- **Control heat flow/ space conditioning requirements (energy)**
- **Control light, solar and other radiation**
- **Control noise**
- **Transfer loads to structure**
- **Be durable**
- **Be constructible**
- **Be maintainable**
- **Control fire and smoke**
- **Provide security**
- **Be aesthetically pleasing and marketable**
- **Provide privacy and views**

All of these functions need to be considered in the complete design of the building envelope and they are often quite interdependent. Satisfying all of these functional requirements is a complex and iterative design process. Numerous and often conflicting

requirements must be satisfied. In addition, although all functions must be appropriately addressed, they are not necessarily all of equal importance.

Building Envelope Commissioning Authority - BECA

The building envelope commissioning program requires a third party consultant (i.e. independent of the design and construction teams) to participate in the design process and oversee/implement testing and third party review during construction. The Building Envelope Commissioning Authority (BECA) must be a specialist in designing, testing and building the specific building envelope assemblies, under the expected environmental conditions (both interior and exterior) on the type of building that is being considered. The responsibility of the BECA throughout the design and construction process should be communicated clearly in the project specifications. The primary role of the BECA is to provide quality assurance services throughout the process, to verify that the building envelope functions to meet the owner's objectives and expectations, and heat, moisture and air flow are all adequately managed. The commissioning authority is rarely the primary designer related to the above functions, however ensuring that all parties integrate their respective design functions at all the assemblies and interfaces between assemblies is the responsibility of the BECA.

Building Envelope Commissioning Activities

Design Phase

The intent of commissioning the building envelope at the design stage is to integrate the expertise of a BECA to assist the designer/architect during conceptual design and production of design documents. The BECA should participate in the entire design process starting with involvement at the preliminary design stage. The BECA conducts peer review of building envelope design documents throughout the design process to identify and suggest corrections for issues in providing a workable building envelope.

More specifically, the building envelope must be reviewed as a whole and at details and assembly interfaces for building envelope functions. Final design drawings need to include details at all typical locations and interfaces between adjacent assemblies. Specific things to review design documents for include:

- Suitability of materials selected for intended use, compatibility and durability
- Suitability of design to manage precipitation, wetting and freeze thaw
    - Durability
    - Deflection of precipitation
    - Drainage
    - Drying
- Continuity of the plane of thermal resistance
- Continuity of the plane of air tightness

- Continuity of the plane of vapour tightness

Design Phase Commissioning Activities

Specific building envelope commissioning activities that take place during the design phase and the individuals involved are outlined in Table 1 as line items A-D. Additional detail about the purpose and expectation of each activity is provided below.

A. Preliminary Design Meeting(s): A preliminary meeting should be held to gather the design team players and the owner to better understand the owner's objectives and expectations for both performance and service life. At this meeting the BECA should review any preliminary design documents that have been prepared and be able to comment on preliminary design ideas such as proposals for building envelope assembly types. The BECA may also be able to identify what kinds of performance testing to include in the contract documents. The basic mechanical design concept should be reviewed in context with the envelope systems to verify compatibility and identify expectations for insulation value, solar shading, and other items affecting heating and cooling loads. Type of roofing systems will also be impacted by the type and density of rooftop mechanical services.

B. Schematic Design and Coordination: Generally the responsibility of the architect and other engineering consultants, the initial schematic designs are prepared. For projects of large scale and/or complexity, the BECA should also participate in this process. Preliminary energy modeling with the design team is encouraged at this phase to inform the design; big wins are often easily attainable at early stages of design.

C. Design Development: During this phase the relevant parties work on coordinating and developing the design. This is when energy modeling and moisture analysis modeling should be completed to support or confirm proposed building envelope designs. During this phase the BECA should review one initial set of Design Development documents to provide feedback in the form of a written summary of issues and concerns noted from the review. At this point, the BECA should draft the building envelope commissioning plan and provide input to the specifications.

D. Construction Document – Peer Review:

    a. The BECA should review the drawings when they are approximately 50% complete and provide a written summary of issues and concerns to the designer/architect. The BECA is responsible for verifying that the specifications include requirements for submission of samples, technical data, mock-up construction expectations, performance testing and details at interface conditions provided on the drawings.

    b. The designer/architect should respond to the 50% review comments by indicating what modifications have been made to address concerns in the subsequent set of drawings provided for final construction documents (95% complete documents). The designer/architect should also notify the BECA of recommendations that were not implemented and the reasoning.

The BECA should review modifications made and also provide written documentation to the owner summarizing any risks that may be associated with unresolved items. Additional computer modeling such as energy modeling and moisture analysis may be required at this stage for further design refinements. The emphasis of the design team should be on long-term durability, performance of the building envelope and materials, and how design decisions will impact the design of the building as a whole.

c. The BECA should review the final documents prior to bidding. The objective is to identify issues and concerns that may compromise the integrity of the envelope. Further, the BECA verifies the specifications include requirements for submission of samples, technical data, mock-up construction expectations, performance testing and details at interface conditions provided on the drawings. In a similar fashion to previous reviews, the modifications that have been made by the designer/architect to address previous BECA reviews should be reviewed again and any recommendations not implemented should be documented in a report to the owner indicating associated risks.

Bid Review and Value Engineering

The BECA should assist with decision making during the bid review process to evaluate the suitability of any proposed product substitutions.

E. If any value engineering of the design and construction of the building takes place, the BECA should be involved in the decision making process of any changes that are proposed. It is important that elements critical to the provision of a quality building envelope not be deleted during the value engineering stage, for example: mock-up installations, performance testing and assembly drainage accessories such as through-wall flashings.

Offsite Prototype Construction and Testing

Offsite prototype construction and testing is recommended when new cladding systems, unique glazing systems or complex arrangements of cladding and glazing are proposed. The construction and testing of an off-site prototype allows a check of constructability and the development of complex 3 dimensional details and sequencing in conjunction with the trades that will be performing the work on the building. Testing of the prototype ensures that the completed assembly is capable of meeting performance requirements.

F. In this phase, it is the BECA's responsibility to define the size, details, and assemblies to be incorporated in the prototype, develop the testing protocol, review the shop drawings, assist in the development of complex details, review the testing and specifically record all repair work performed during the testing. Once completed the BECA verifies that the lessons learned during the construction and testing of the prototype are carried over to the design details and installation practices during construction.

Construction Start-Up/Pre-Construction Phase

The intent of building envelope commissioning activities at the initialization of the construction project is to communicate building envelope quality expectations to the relevant project parties before any typical installations have begun. Specific building envelope commissioning activities that take place during the construction start-up phase and the individuals involved are outlined in Table 1, as line items G-J.

G. Shop Drawing and Submittals Review: BECA to perform 3rd party review in addition to designer/architect, after designer/architect has reviewed, for a sample of submittals at the discretion of BECA and owner.

H. Prior to construction a coordination meeting should take place to discuss construction sequencing, coordinate trades and to communicate reporting requirements of the building envelope commissioning program. The coordination meeting is under the direction of the BECA and includes all members of the design and construction team and owners representatives. Items such as mock-up installation and performance testing will be communicated to the team, and preliminary arrangements can be discussed.

I. The BECA should conduct pre-installation meetings with individual trades to communicate the expectations of each party and the stages along the construction process where building envelope commissioning activities will take place.

J. One or more full scale mock-ups representative of typical envelope assemblies should be installed to verify the constructability of the building envelope design. Where feasible, mock-ups should be built onsite in-situ at a location chosen by the BECA. When necessary, mock-ups can be located nearby. Mock-ups should be built by installers that will be used for the remainder of the job. Mock-up assemblies will typically be required to undergo field testing to verify that proposed performance requirements can be achieved. Iterative changes to the design required to meet performance requirements will become amendments to the construction documents. Ensure the mock-up and performance testing requirements are included in the contract documents. The final mock-up that passes performance testing should be kept as a sample for the duration of the project, as an onsite record of what is expected. Field review and testing to be performed on mock-up assemblies include:

- Visual examination of each stage of installation and finished assemblies to confirm conformance to project design documents
- Documentation of installation sequence
- Material compatibility testing and/or documentation
- Water penetration resistance testing and documentation (See Table 3 at end of document for summary of tests.)

    - Test Standard: ASTM E 1105 – Standard test method for field determination of water penetration of installed exterior windows, skylights, doors and curtain walls by uniform of cyclic static air pressure difference
    - Minimum Acceptable Test Level: To be Determined by BECA and Alberta Infrastructure
    - AAMA 501.2 – Field check for quality assurance (if required)
- Air leakage testing and documentation
    - Test Standard: ASTM E 1186-03(2009) - Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems. Test to a minimum 75Pa pressure difference.
    - Minimum Acceptable Test Level: no significant air leakage through assembly
    - Smoke tracer testing under pressurization

The visual examination should be done by the designer/architect and the BECA over the course of construction. Testing should be conducted by the BECA or an independent testing agency with the designer, general contractor, subcontractor and window manufacturer present.

Construction Phase – Ongoing Field Review and Quality Assurance Services

The intent of building envelope commissioning during the construction process is to review construction progress and verify installation of building envelope components conform to the owners requirements. It is important that the general contractor have a quality assurance inspection plan developed for the execution of installing envelope components. The BECA should review the quality assurance inspection plan and provide feedback where required.

Periodic review of building envelope installation should be conducted by the BECA throughout the duration of construction. Deficiencies and any unique conditions not adequately covered in the design should be recorded and forwarded to the designer/engineer of record as well as the general contractor in a timely manner to allow for necessary corrective action to take place. Periodic water penetration and air leakage testing is also recommended during the installation process as required at the discretion of the BECA. Smoke testing in particular should be performed at least once for each unique air barrier interface detail. This type of testing is a useful quality assurance tool, particularly if quality of installation is poor or installers have had difficulties passing or repairing previous tests. There is one building envelope activity listed in Table 1, line item K to conduct field review, further details are provided below.

K. Field review and testing to be performed on building envelope assemblies include (See Table 3 at end of document for summary of tests.):

- Visual examination between stages of significant components and of finished assemblies
- Water penetration resistance testing and documentation (as required)
    - Test Standard: AAMA 501.2 – Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems
    - Minimum acceptable test performance: no leakage to the interior
    - Frequency of testing: To be determined by Alberta Infrastructure and BECA
- Air leakage testing and documentation
    - Test Standard: ASTM E 1186-03(2009) – Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems complete with smoke and pressure
    - Minimum acceptable test performance: no significant air leakage through assembly
    - Frequency of testing: To be determined by Alberta Infrastructure and BECA

The visual examination should be done by the designer/architect and the BECA over the course of construction. Testing should be conducted by the BECA or an independent testing agency with the designer, general contractor, subcontractor and window manufacturer present.

Project Close Out – Final Walk Through, Deficiency Sign Off and Summary Reporting

At the final stages of construction a final walk through should be done by the BECA, designer and owner to review for deficiencies and conduct final sign off procedures. This is shown as item L in Table 1.

At this time the BECA should direct whole building testing using infrared thermography to verify performance of installed assemblies and provide information that may be used for future designs of buildings or issues that need to be addressed. (See Table 3 at end of document for summary of tests.)

- Thermal Performance Test Standard: Conduct thermographic scan under minimum 30 Pa positive and negative pressure and minimum temperature differential of 20 Celsius degrees across the building envelope using ASTM E1186 - 03(2009) Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems.
    - Minimum acceptable performance: No significant air leakage or thermal bridging.

The BECA will prepare a summary report outlining the Building Envelope Commissioning program that was undertaken including results of reviews and testing performed throughout the project.

Post Construction

The final step is for the BECA to facilitate training of the owner's representatives in maintaining the building envelope assemblies (M). BECA should also carry out warranty reviews of envelope assemblies just prior to the expiration of their specific warranties (N). The Owner is encouraged to conduct maintenance reviews every 5 years to ensure adequate maintenance is being performed.

Table 3 Test methods for building envelope components, Parties Involved and time for testing

Test Method	Test Title	Building Envelope Elements To Test	Reviewed By	When to Conduct Testing		
				Mock-Up	During Construction	Post Construction
ASTM E 1105	Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform or Cyclic Static Air Pressure Difference	Windows and Window/Wall Interface	BECA/Architect/Contractor	X	X	
ASTM E 1186	Practices for Air Leakage Site Detection in Building Envelopes and Air Retarder Systems	Windows/Walls/Roof Interfaces	BECA and Contractor	X	X	
		Whole Building				X
AAMA 501.2	Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems	Windows and Window/Wall Interfaces		X	X	