

INTEGRATED INFRASTRUCTURE SERVICES

Facility Engineering Services

Facility Planning & Design

Facility Infrastructure Delivery



Facility Commissioning Consultant Manual

Volume 2

COE-IM-GUIDE-0028

Building Envelope Commissioning Process and Guidelines v2.0

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02	2024-07-16	Additions / revisions highlighted in light orange. Document renamed to 'Facility Commissioning Consultant Manual - Volume 2 - Building Envelope Commissioning Process & Guidelines'. Formerly the document was titled 'Commissioning Consultant Manual - Volume 2 - Building Envelope Commissioning Process & Guidelines'.
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1 Introduction

1.1 Purpose and Scope

- .1 This document is intended to be used for the following purposes:
 - .1 A reference for consultants providing Building envelope commissioning services (herein defined as the Building Envelope Commissioning Authority (BECA) for new building projects, renovations to existing facilities or re-commissioning of existing buildings owned or operated by the City of Edmonton.
 - .2 A resource for the City of Edmonton when reviewing and evaluating the work performed by commissioning firms on City projects.
- .2 This document forms part of the Commissioning Manual.
 - .1 Commissioning Consultant Manual Volume 1 - *Whole Building Commissioning Process & Guidelines* and,
 - .2 Commissioning Consultant Manual Volume 2 - *Building Envelope Commissioning Process and Guidelines*.
 - .3 Volume 2 is divided into the following sections:

Section 1 – Introduction:

Establishes the scope of the document and gives general contact information.

Section 2 – Building Envelope Commissioning Process:

Describes the information flow on a typical project, standard deliverables expected at each phase and an overview of minimum document standards to be followed.

Appendices

- .3 Except where otherwise noted, the technical information contained in this document is to be used as a guide only. The Consultant is expected to follow their own professional judgment and best practices as well as all applicable codes and regulations. Building projects may have specific requirements that supersede some material presented in this document. These requirements will be communicated to the Consultant at the outset of the project or during design as the need arises. When a deviation from these guidelines is either required or requested by the Consultant or Owner, it shall be documented in writing.

1.2 Sources

Building Commissioning Association – [New Construction Building Commissioning Best Practice 2016](#)

LEED v4, Canada Green Building Council

Canada Standards Association Z320-11 Building Commissioning

Natural Resources Canada – 1st Edition Commissioning Guide for New Buildings

ASTM E2947-16a “Standard guide for Building Enclosure Commissioning”

[Technical Resource- Government of Alberta](#)

[NIBS Guideline 3-2012 Building Enclosure Commissioning Process BECx](#)

1.3 Definitions

Basis of Design (BOD)	A document that records the concepts, calculations, decisions, and product selections used to meet the Owner’s Project Requirements (OPR) and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process. (Also known as the Design Criteria).
BECA	Building Envelope Commissioning Authority (An entity identified by the Owner who leads, plans, schedules, and coordinates the Building Envelope Commissioning Process).
BECx	Building Envelope Commissioning
Building Envelope	The building envelope includes systems separating one defined environment from another, including walls, fenestration, roofing and roof openings, floors and or ceilings, below grade perimeter walls, crawlspaces and attics from the interior, slabs-on-grade and below grade perimeter walls and interior walls and floor/ceiling assemblies separating interior zones with differing performance criteria.
Building Envelope Commissioning Plan (BECx Plan)	A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Building Envelope Commissioning Process.
Building Envelope Commissioning Process	A quality focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility assemblies are planned, designed, installed, tested, operated and maintained to meet the Owner’s Project Requirements (OPR).

Building Envelope Commissioning Review	A collaborative detailed review of design documents for items pertaining to the following: Owner's Project Requirements (OPR); Basis of Design (BOD); operability and maintainability (O&M) including documentation; functionality; training; energy efficiency, control systems' sequence of operations including building automation system features; commissioning specifications and the ability to functionally test the systems.
Check Sheet	Project and element specific check sheets that are developed and used during all phases of the Building Envelope Commissioning Process to verify that the Owner's Project Requirements (OPR) are being achieved. This check sheet is used by the Contractor and BECA to verify that appropriate components are onsite, ready for installation, correctly installed, and functional prior to system Functional Performance Tests (FPTs).
Code Compliance Review	A review of a document conducted by staff or designated entity of an authority having jurisdiction to determine whether the content of the document complies with regulations, codes, or other standards administered by the jurisdiction.
Commissioning Team (Cx Team)	A team comprised of the BECA, Whole Building Commissioning Agent (Cx), Owner, A/E, Construction Manager/General Contractor, Contractors, maintenance and operations personnel, and occupants. Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action.
Constructability Review	A review of effective and timely integration of construction knowledge into the conceptual planning, design, construction, and field operation of a project to achieve project objectives efficiently and accurately at the most cost-effective levels to reduce or prevent errors, delays, and cost overruns.
Construction Documents	Usually includes the project manual (specifications), plans (drawings), general terms and conditions of the contract and supporting documentation such as change orders and submittals.
Construction Manager (CM)	The Owner's representative managing the construction project. Often the construction manager and the general contractor are the same entity.

Construction Team	A team comprised of Construction Manager/General Contractor, subcontractors and equipment vendors and suppliers.
Contractor	The general contractor's or subcontractor's authorized representative.
Contract Documents	The documents binding on parties involved in the construction of the project (drawings, specifications, change orders, amendments, contracts, BCx Plan, etc).
Coordination Drawings	Drawings showing the work of all trades to illustrate that equipment can be installed in the space allocated without compromising equipment function or access for maintenance or replacement. These drawings graphically illustrate and dimension manufacturers' recommended maintenance clearances.
Current Facility Requirements (CFR)	A written document that details the current functional requirements of an existing facility and the expectations of how it should be used and operated.
Cx Progress Report	A written document that details activities completed as part of the Envelope Commissioning Process and significant findings from those activities, and is continuously updated during the course of a project.
Design Checklist	A form developed by the Commissioning Team to verify that elements of the design are in compliance with the Owner's Project Requirements (OPR). Also see Checklists.
Design Review (As in Peer Review)	An independent and objective technical review of the design, project or a part thereof, conducted at specified stages of design completion by one or more qualified professionals, for the purpose of enhancing the quality of the design.
Design Team	The professionals (architects, engineers and consultants) responsible for developing the project's design concepts, interim and final drawings, specifications and Basis of Design (BOD).
Facility Guide	A basic building systems description and operating plan with general procedures and confirmed facility operating conditions, set-points, schedules, and operating procedures for use by facility operations to properly operate the facility.
Final building Envelope	A document that records the activities and results of the Building Envelope Commissioning Process (BECx Process) and is developed

Commissioning (BECx) Report	from the final Commissioning Plan (BECx Plan) with all of its attached appendices.
Functional Program (FP)	A document prepared by the Owner or Architect that describes the facility's space and function requirements.
Issues & Resolutions Log	A formal and ongoing record of problems or concerns and their resolution that have been raised by members of the Commissioning Team during the course of the Commissioning Process.
Operations and Maintenance (O&M) Manual	A manual to describe key components of each system or piece of equipment and explain how they should be operated and maintained for optimum performance.
Owner (CoE)	City of Edmonton, and or the Building User Group.
Owner's Project Requirements (OPR)	A written document that details the functional requirements of a project and the expectations of how it will be used and operated. These include project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.
PC (Prime Consultant)	The design specialist or firm retained to design, provide technical opinions on or advise on the design of the scope of work as requested or required by the Owner. This entity is responsible for the validity of the design or components of the design they are designing or advising on.
Project Manager (PM)	The contracting and managing authority for the Owner who oversees the design and/or construction of the project.
Professional Services Agreement (PSA)	The contract the Consultant enters into with the Owner to perform the Work. This document includes the Agreement Form, Description of Work, Payment Terms, General Terms, and Additional Terms (if applicable).
Sampling	Performing observation, review, testing or other verification on only a fraction of the total number of identical or near identical pieces of equipment, drawings, events, etc. Sampling techniques include random statistical sampling and less formal professional judgment methods.
Seasonal Testing	See 'Deferred Testing'.

Warranty Period The period of time in which the contractor is responsible for equipment repairs following turnover to the Owner, as defined in the construction contract.

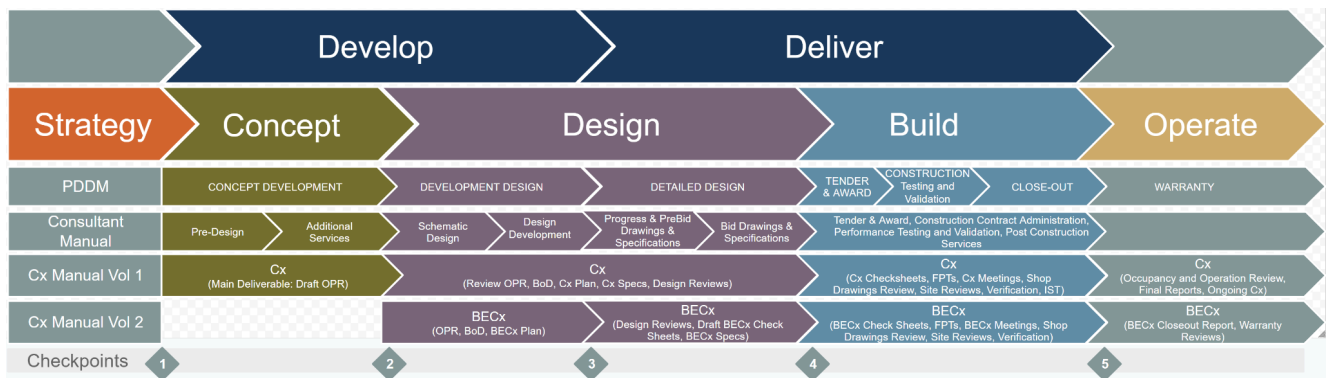
1.4 Contact Information

- .1 The latest version of this document is available online under resources of the [City Design and Construction Standards](#) on the City of Edmonton website.

2 Commissioning Process

2.1 Project Development and Delivery Model (PDDM)

2.1.1 The Project Development and Delivery Model (PDDM) is the approach that the City takes to enhance capital infrastructure project oversight. This process involves structured reviews of projects at key points throughout the Project lifecycle. Below is an illustration of the approximate alignment of Design Team and BECx Provider deliverables with the City's internal PDDM checkpoint system.



2.2 Project Communication

2.2.1 General

- .1 The City of Edmonton will assign a Project Manager (PM) to be the single point of contact with the City (herein identified as the Owner). The project will be handed over internally from the Facility Planning and Development (FPD) PM to the Facilities Infrastructure Delivery (FID) PM at what is defined in the PDDM as Checkpoint 3. This is typically after the design development phase.
- .2 The BECA Firm is to appoint one person to act as the primary contact and to lead the BECx Process. If the BECA team consists of multiple sub-consultants in multiple firms,

all official correspondence and submissions to the Owner should be through the BECA's primary contact.

- .3 Internal discussions between the BECA and their sub-consultants are to be documented internally. It is the responsibility of the BECA to alert the Owner's Project Manager of any internal discussions that may affect the project scope, budget, schedule, etc.
- .4 Commissioning meeting minutes and similar documentation are the responsibility of the BECA and should be distributed to the Owner PM, Consultant (including sub-consultants), Owner-identified stakeholders and other parties as necessary.
- .5 Addendums and construction documents such as contemplated change orders, site instructions, and shop drawings are to be distributed to the BECA by the Owner's PM.

2.3 Commissioning Consultant Services

2.3.1 Introduction

- .1 This section outlines typical deliverables at key project milestones. It is understood that all projects are different and the contents of this section may not apply to all projects in its entirety. For example, a larger project may be phased in such a way that more or less is required from the Consultant at each separate phase.
- .2 Specific submissions required are identified herein. In addition to the deliverables identified herein, it is the responsibility of the Consultant to prepare any submittals required by external authorities.
- .3 The BECA is responsible for ensuring they are aware of the project deliverables and prepare these submissions on time, with all required information contained therein. Consultant Deliverables and Milestone schedule will be defined on a project by project basis in the Request for Proposal/Project Call-up.
- .4 All BECA submissions will be reviewed by Owner staff or external consultants associated with the project. This may include PM's, Architects, Technical Services, Client groups, Building Maintenance, etc. All review comments will be forwarded to the Consultant by the Owner's PM.
 - .1 The BECA is to respond to all review comments in writing to the Owner's Project Manager prior to commencing work on the next submission.
 - .2 Deliverables submitted to the Owner shall follow naming conventions as outlined in the Commissioning Consultant Manual Vol 2 - Building Envelope Commissioning Process & Guidelines, herein.
- .5 For all projects requiring Building Envelope Commissioning, the Owner expects that all of these tasks will be completed unless any proposed changes to the task list are clearly identified in the BECA's proposal and subsequently agreed to, in writing, by the Owner.
- .6 On any projects targeting LEED® certification; the BECA shall include in their proposal and estimate all work related to achieving all of the enhanced commission requirement points of LEED.

- .7 Whole Building (M&E) Commissioning is not considered to be a component of Building Envelope Commissioning as defined within this document. For Whole Building (M&E) Commissioning requirements, refer to Commissioning Consultant Manual - Volume 1. When coordination between the BECA responsible for Building Envelope Commissioning and the CxA responsible for Whole Building (M&E) commissioning occurs, the expectation of the Owner is that both parties will coordinate and collaborate to ensure a seamless development of common deliverables to both scopes of work and, on occasion, provide support and feedback regarding related documentation. Each project call-up/Request for Proposal will define who will take lead roles in creation of the base document(s), collect and amalgamate data, and who will provide input.

2.3.2 Design Phase

2.3.2.1 Deliverables

- .1 Owner's Project Requirements (OPR)
1. The OPR is a compilation of all documentation on the owner's goals, objectives, and expectations for the project. The BECA shall assist the owner by recommending any additional information required to create an accurate and project specific OPR. The BECA is also responsible for advising of any updates to the envelope related sections of the OPR, as they become apparent through all phases of the project. Each proposed update must be formally reviewed and approved by the City Project Team (Project manager & Project Architect) prior to acceptance and implementation.
 2. Additional OPR Support Services:
 1. Projects may request additional support for OPR development, and will be defined on a project-by-project basis, at Project Call-up. Services may include, but are not limited to, reviewing existing City documentation, participating in focus groups and interviews with City stakeholders as required in developing a comprehensive OPR. The intent of the additional support is to have the BECA assist the owner in creating a complete OPR with all necessary references to relevant Owner requirement documents and Codes.
 1. The Owner may provide the following documents, when available, to aid the BECA in the development of the OPR:
 - .1 Project Charter,
 - .2 Facility Design and Construction Consultant Manual, Vol 1 and Vol 2,
 - .3 Commissioning Consultant Manual Vol 1,
 - .4 Owner Directives/Mandates (relevant to the project),
 - .5 Functional Program,

.6 Other relevant documentation and policies

.2 Basis of Design (BOD)

1. BECA shall generate the BOD only if the Prime Consultant (PC) has not provided the record and the document is required by the CaGBC LEED or other regulatory body.
2. Where possible, the BECA's BOD document shall be coordinated and issued in conjunction with the Whole Building Commissioning BOD (Refer to Commissioning Consultant Manual Volume 1)

.3 Building Envelope Commissioning Plan (BECx Plan)

1. The BECA is responsible for developing the BECx Plan, updating and issuing this record to the Owner for review *during each milestone deliverable of the project* lifecycle (refer to the project call up for milestones). The BECx Plan shall include, at a minimum, the following information:
 - .1 Overview of the BECx Process developed specifically for the project.
 2. Roles and responsibilities for the BECx Team throughout the project.
 3. Documentation of general communication channels to be used throughout the project.
 4. Detailed description of the BECx Process activities and schedule. The following items to be included:
 - .1 BECx Team meetings
 - .2 Verification of the OPR adherence
 - .3 Advisory on OPR improvements that may be of benefit to the project.
 - .4 Design review process
 - .5 Commissioning specifications
 5. General description of BECx Process activities that will occur during the Construction and Occupancy/Operations Phases.
 6. Guidelines and format that will be used during the Design Phase to communicate, track, document and report critical BECx Process information.
 7. Project design document verification procedures. Including alerts to coordination issues, issue reporting and deficiency resolution
 8. BECx Checksheet use, verification and compilation procedure.
 9. Where possible, the BECx Plan shall be coordinated and issued in conjunction with the Whole Building Commissioning Plan (Refer to Commissioning Consultant Manual Volume 1)

.4 Cx Issues & Resolutions Log

1. The BECx Issues & Resolutions Log is to record all identified BECx related issues and the solutions. The BECA is responsible for creating and maintaining the BECx Issues & Resolution Log for the duration of the project. A copy of the BECx Issue & Resolution log is to be included in the Final Commissioning BECx Report, and shall include all issues that were closed through the Cx process, as well as any remaining outstanding issues.
 1. Where possible BECx Issues & Resolutions log shall be coordinated and issued in conjunction with the Whole Building Commissioning Issues & Resolutions log (Refer to Commissioning Consultant Manual Volume 1)
2. The Cx Issues & Resolutions Log shall comply with the guidelines set out by template listed in Appendix A and must include the following:
 1. Unique numeric identifier by which the issues may be tracked
 2. Short, descriptive title of the issue(s)
 3. Date and time of the identification of the issue(s)
 4. Test number of the test being performed at the time of the observation, if applicable, for cross-reference
 5. Identification of assembly to which the issue applies
 6. Location of the issue
 7. Description of the observed design, installation, or performance issue, including any information that may be helpful in diagnosing or evaluating the issue(s)
 8. Recommended corrective action
 9. Identification of the Cx Team member responsible for resolution of the issue
 10. Expected date of correction
 11. Date of completion of resolution
 12. Description of corrective action taken. Including description of diagnostic steps taken to determine the root cause of the issue and the value of resolving the Cx Process issue for the owner, design team, contractor, and/or occupant
 13. Identification of changes to the OPR or BOD that require action (if any)

14. Statement that the correction was completed and the system or assembly is ready for retest, if applicable
 15. Name of the person who resolved the issue
- .5 Design Phase Kickoff Meeting
1. The BECA to schedule and chair an initial Kickoff Meeting with the City, Design consultant and the Design Phase Whole Building Commissioning Team (Cx Team(when applicable), within fifteen (15) days of appointment to establish the purpose and proposed process for commissioning the design and to review the Design Phase BECx Plan. The Design Phase Kickoff meeting is to include the following:
 1. Review of the OPR and BECx Plan with the Design Cx Team,
 2. Review of the various commissioning activities and schedules,
 3. Review of the documentation requirements,
 4. Review of communication and reporting procedures,
 2. Meeting minutes to be distributed within 72 hours of each meeting.
- .6 Design Submission Reviews
- .1 Perform commissioning design reviews of the Schematic Design, Design Development, Progress Submission, and Pre-Bid Submissions , and provide in writing formal feedback of issues and concerns.
 1. Review suitability of materials selected for intended use, compatibility and durability.
 2. Review occupant comfort requirements, site information and climate conditions outlined in the OPR, Functional Program and design submissions as they relate to the BECx.
 3. Identify issues and concerns that may compromise the integrity of the envelope.
 4. At the request of the City within the Project's Scope of Work, review of the energy model, wind and snow analysis etc. to support or confirm proposed building envelope designs will conform with the OPR.
 5. Verify that the technical specifications include the requirements for submission of samples, technical data, [mock-up construction expectations](#), performance testing, Building Envelope Construction Commissioning check sheets, as appropriate.
 6. Verify the quantity and type of tests in contract for the project and recommend to the owner any additional field performance test(s) that may benefit the project.

7. Verify details at interface conditions provided on the drawings, (including any typical conditions which may affect environmental separation performance).
 8. Any 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.
 9. All the Design Submission Reviews are to be recorded in the BECx Issues & Resolutions Log.
- .2 Design Phase Meetings:
- .1 Participate in **Project design meetings** as required to ensure proper integration of OPR and identify issues with the envelope that may affect functional performance.
 - .2 Schedule and lead **Building Envelope Commissioning Coordination Meetings** with the Cx Team, as required but at a minimum of four (4) half-day sessions, to ensure successful coordination of the design phase commissioning activities and development of the OPR. Scheduling of meetings to be coordinated with the Owner Project Manager. Prepare and distribute commissioning meeting minutes to all Cx Team members within 72 hours of each meeting.
 - .3 Exact number of Design Phase Meetings to be determined in conjunction with the Owner's Project Manager at each proposal submission.
- .3 Commissioning Specifications
- .1 Develop full Building Envelope Commissioning Specifications for all commissioned assemblies and spaces. Coordinate this with the design team and integrate the Commissioning Specifications into the overall project specification bid package. The basis for documents can be acquired from [NIBS Guideline 3-2012](#). Commissioning Specifications to include:
 1. 01 91 13 General Building Envelope Commissioning Requirements
 2. 01 91 13.13 Building Envelope Commissioning Plan (*BECx Plan*)
 - .4 Develop draft Building Envelope Construction Commissioning Check Sheets (BECx Check Sheets)
 - .1 Refer to [NIBS Guideline 3-2012](#) Annex M: Construction Checklists, for sample Commissioning Construction Check Sheet.
 - .2 The check sheets are created by the BECA for incorporation into the Project Manual(prior to tender), filled out by the Contractor during construction and used by the BECA to verify that appropriate components are onsite, ready for

installation, correctly installed, and functional prior to system Performance Tests.

- .3 BECA shall be responsible for compiling contractor performed check sheets for the progress and final commissioning report deliverable.
- .5 Develop, update and Issue to the owner a Draft Project Manual (Specification) Sections for inclusion in the Tender Document, incorporating changes to the project requirements a result of the design submissions, or subsequent discussions;
 - .1 01 91 13 General Building Envelope Commissioning Requirements
 - .2 01 91 13.13 Building Envelope Commissioning Plan (BECx Plan)
 - .3 01 91 13.16 Building Envelope Commissioning Construction Check Sheets

2.3.2.2 Bid and Construction Documents

- .1 Update and Issue to the owner final project Manual (Specification) Sections for inclusion in the Bid and Construction documents, incorporating changes to the project requirements a result of the Design submissions, or subsequent discussions;
 - .1 01 91 13 General Building Envelope Commissioning Requirements
 - .2 01 91 13.13 Building Envelope Commissioning Plan (BECx Plan)
 - .3 01 91 13.16 Building Envelope Commissioning Construction Check Sheets
- .2 Provide Commissioning (BECx) Progress Report
 - .1 The Design Phase BECx Progress Report is to include the following:
 - .2 Intent
 - .3 Executive Summary
 - .4 Commissioning Overview
 - .5 [OPR](#)
 - .6 [BOD](#)
 - .7 [BECx Plan](#)
 - .8 Commissioning Specifications
 - .9 Summary of the Design Review Process
 - .10 [Issues & Resolutions](#) Log (to date)
 - .11 Issues & Resolutions Report (since last review)
 - .12 Building Envelope Commissioning Construction (BECx Check Sheets)
- .3 Design Phase Close-out

- .4 Design Phase Commissioning is complete when the final design team Contract Documents are complete.
- .5 Required Documentation from this Phase includes:
 - .1 Cx Progress Report

2.3.3 Bid Phase

2.3.3.1 Bidding Phase

- .1 The BECA should assist with decision making during the bid review process to evaluate the suitability of any proposed product alternates and substitutes (if any).
- .2 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.
- .3 If any new materials are being proposed BECA may ask for an off-site testing of the materials to check their durability. By all means BECA will verify that the materials that are being proposed for the project will meet all OPR.

2.3.4 Construction Phase

2.3.4.1. Pre-Construction

- .1 At the request of the City Project Manager, the BECA shall review envelope related shop drawings, and product selections and advise the City of errors and concerns to be distributed to the PC and/or GC.
- .2 Construction Phase Kickoff Commissioning Meeting
 - .1 BECA to schedule and chair an initial Kickoff Meeting with the Construction Phase Commissioning Team, including subcontractors, construction team and owner representatives, within fifteen (15) days of appointment to establish the purpose and proposed process for commissioning and to review the Construction Phase Commissioning Plan. The Construction Phase Kickoff meeting is to include the following:
 - .1 Review of Cx Plan with the Construction Cx Team
 - .2 Review of the various commissioning activities, tests and schedules
 - .3 Review of the documentation requirements
 - .4 Review of construction sequencing, communication and reporting procedures
 - .5 Review mockup installations, preparatory procedures and performance testing
 - .3 Pre-installation Meetings

- .1 BECA to schedule with the General Contractor and individual trades to communicate the expectations of each party and the stages along the construction process where building envelope commissioning activities will take place.
- .2 The BECA shall review the general contractor's quality assurance inspection plan developed for the execution of installing envelope components, which should include the BECA developed check sheets, and provide feedback where required.
- .3 BECA shall provide samples of check sheet/QAQC documents for inclusion into the PC working document "01 91 13.16 Commissioning Forms" specifications, that will need to be filled by various sub-trades and will also explain the process and stages how they will be required to fill.

2.3.4.2. Construction

- .1 The intent of building envelope commissioning during the construction process is to review construction progress and verify installation of building envelope components conform to check sheet requirements and meet the owner's requirements.
- .2 Construction Meetings
 - .1 Attend selected planning and job-site meetings to obtain information on construction progress. Review construction meeting minutes for revisions/substitutions relating to the BECx Process. Assist in resolving any discrepancies.
 - .2 Plan and conduct Commissioning Progress updates at Construction Meetings, as required. Exact number of construction meetings to be determined in conjunction with the Owner's Project Manager at each proposal submission.
- .3 Field Reviews
 - .1 Perform field reviews, as necessary to verify that construction complies with the Contract Documents and the OPR, and to identify and document and quality issues that may lead to functional issues. Provide feedback on the correct installation and serviceability of the equipment being installed. Field Reviews are to be recorded in the Cx Issues & Resolutions Log. Exact number of field reviews to be determined at each proposal submission, and may vary by size and type of construction.
 - .2 Deficiencies and any unique conditions not adequately covered in the design, which should result in a change, should be recorded and forwarded to the City PM with copies to the PC, designer/engineer of record as well as the GC in a timely manner to allow for necessary corrective action to take place.

- .3 Mock-ups: BECA to review any required mock-ups of envelope assemblies. Mockups should be constructed and used to verify the constructability and performance of the building envelope design. Where feasible, mock-ups should be built onsite in-situ at a location chosen by the BECA. Mock-ups should be built by installers that will be used for the remainder of the job. Mock-up assemblies will 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:
 - .1 Visual examination of each stage of installation and finished assemblies to confirm conformance to project design documents. Take pictures during the process. Review of continuity of moisture barrier, air/vapour barrier and thermal insulation.
 - .2 Documentation of installation sequence
 - .3 Material compatibility testing and/or documentation
 - .4 As a minimum mock-ups to be created for all typical envelope assemblies and the following interfaces: roof/roof deck, wall/soffit, wall/roof, wall/window, and roof penetrations.
- .4 Minimum Testing Functional Performance Test Standards:
 - .1 Water penetration resistance testing and documentation
 - .1 Test Standard: ASTM E1105 – 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
 - .2 Minimum Acceptable Test Level: To be Determined by BECA and COE and defined within OPR.
 - .3 AAMA 501.2 – "Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems"
 - .4 AAMA 502- field air leakage resistance and water penetration resistance testing of operable windows and doors.
 - .2 Air leakage testing and documentation
 - .1 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 and/or, ASTM Standard E799-87, Test Method for Determining Air Leakage by Fan Pressurization.

- .2 Minimum Acceptable Test Level: As defined in the OPR, no significant air leakage through assembly
 - .7 Smoke tracer testing with Building Pressure Manipulation and documentation and/or,
 - .8 Blower Door Testing and documentation: To be conducted using calibrated door fans to give a reasonably accurate estimate of building infiltration. Building infiltration numbers at 75 Pa and 15 Pa to be included in the report. Comment on pressurization, air sealing, weather stripping, exterior door and window frames. Measure actual building pressurization at two doors. Identify in audit any potential areas of infiltration and smoke test any spots identified. Include in the report infiltration values in L/s per m² of floor area and L/s per m² of envelope area. Measurements to be performed by a qualified technician with minimum 2 years of experience in blower door testing. Blower door testing to occur during off hours.
- .3 Infrared Imaging with Building Pressure Manipulation and interpretation documentation
 - .1 Test Standard:
 1. ASTM E 1186-03(2009) - Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems
 2. ASTM E779 - Standard Test Method for Determining Air Leakage Rate by Fan Pressurization, ASTM C1060 - Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings
 - .2 Refer to Section 2.2.4.6 Additional Requirements for Infrared Imaging testing requirements, quantities and interpretation documentation requirements.

2.3.4.3. Project Closeout

- .1 At the final stages of construction a final walk through should be done by the BECA, design team and owner to review for deficiencies and conduct final sign off procedures.
- .2 Commissioning Closeout Report; to be prepared by BECA. The report should be complete in respect to:
 - .1 [Owner Project Requirements \(OPR\)](#)

- .2 [Basis of Design \(BOD\)](#)
- .3 Applicable Third Party/In house Testing Reports
- .4 Building Envelope Field Visit and Testing Reports and/or Testing Interpretation Reports.
- .5 [Final BECx Issues & Resolutions Log Report](#)
- .6 Completed Building Envelope Commissioning Construction Checksheets (BECx Check Sheets)
- .7 Final Summary Report on Building Envelope Status (benchmarks) including any remediation & Retest Reports and/or recommendations for any remaining performance improvements
- .8 The Final Commissioning Report shall also contain tab sections for inserting the following:
 - .1 Seasonal Deferred Commissioning Plan (SDCP) results
 - .2 Near Warranty End Review Report and suggestions for operations improvements (if any)

2.3.5 Additional Services

Additional Services will be defined on a project by project basis within the Description of Work document in the project Call-up and/or Request for proposal. Additional Services may include:

- .1 Infrared (IR) Imaging of Buildings Envelope with Building Pressure Manipulation and Interpretation Report:
 - .1 Thermographic Testing:

Performed by a qualified technician with a minimum certified level 1 thermographer with minimum 2 years of experience in thermal scanning

 - .1 ASTM E 1186-03(2009) - Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems
 - .2 Unless indicated otherwise in the project call-up, the consultant shall provide two similar scans, once under positive pressure then again under negative pressure. This is to provide additional clarity and documentation on the cause of anomalies (heat loss due to thermal bridging/insulation vs. air leakage).
 - .1 Under positive pressure, you will get anomalies that are either heat loss (insulation/thermal bridging) or air leakage.
 - .2 Under negative pressure, you shouldn't get as much air leakage and so if there is a reduction in anomalies, it is likely indicative of an air leak at those areas.
 - .3 Survey all exterior building elevations and roof areas, such that each exterior surface is shot from a variety of vantage angles to improve the quality of the

interpretation and to eliminate the effect of phenomena such as reflection from light sources, background radiation, and corner effects.

- .4 Prior to the test, BECA to hold a coordination meeting with the Owner, Facility Maintenance and/or the General Contractor to explain the process;
 - .1 any building preparatory work outlined in the scope of the contractor to be completed to ensure proper commissioning results; including sealing of vents, exhausts, plumbing traps, ensuring all systems are working, and in situ pressurization or coordination with other air leakage testing that may be required to ensure an accurate evaluation of barrier performance.
 - .2 coordination required for in scope/third party monitoring of pressurization prior to, during, and following the survey to ensure that accurate results from the exterior could be achieved.
 - .5 Acceptable Environmental Condition for testing:
 - .1 Minimum 20 degree celsius degree differential interior to exterior. (Preferred is -10 outside temperature with 20+degree interior temperature)
 - .2 No direct sunlight (i.e. in the pre-dawn hours or in the evening) in order to reduce the effects that ultraviolet radiation has on the thermographic survey results.
 - .3 Under conditions when precipitation (snow or rain) can not influence the atmosphere in which the instrument had to operate.
 - .6 Refer to Section 2.2.4.3. Whole Building Air Leakage and Infrared Thermography minimum testing standards.
- .2 Infrared (IR) Imaging of Buildings Envelope with Building Pressure Manipulation Interpretation Report:
 - .1 Background: Facility name, location, date of facility construction, date, time.
 - .2 Methodology: Technician name and qualifications, thermal Imaging System type
 - .3 Survey Conditions: Level of pressurization (exterior, interior), weather, outside air temperature and inside air temperature, environmental conditions.
 - .4 Observations:
 - .1 Estimated Exterior wall, roof, door and glazing construction assemblies and thermal resistance values based on thermal scanning and owner supplied documentation.
 - .2 Thermographic imagery with corresponding photographs/location, thermal scale and annotations highlighting thermal anomalies and their corresponding source (air leakage, moisture intrusion, heat loss,

inadequately adhered barriers, missing caulking, thermal bridging, cracks etc.)

- .5 **Conclusions & Recommendations:** Provide analysis of survey findings with a table summarizing observations, reference to images, remedial repair solutions, area requiring physical verification, and estimation of the effectiveness of possible repairs.
- .3 Infrared (IR) Imaging of Buildings Envelope Report Follow Up:
 - .1 Provide Infrared (IR) Imaging of Buildings Envelope and Interpretation Report to the same standards and conditions of initial testing and report to provide measurement and verification of the effectiveness of repairs.
- .2 LEED - Enhanced Envelope Commissioning
 - .1 The consultant may also be asked, on an individual project basis, to complete all the tasks associated with the LEED v4 Enhanced and Monitoring-Based Commissioning and Envelope Commissioning.
 - .2 If required by LEED v4 EA: EC opt2 (BECx), BECA shall review building operations 10 months after substantial completion.
- .3 Warranty Reviews
 - .1 BECA should also carry out warranty reviews of envelope assemblies just prior to the expiration of their specific warranties.

2.3.6 Limit of Responsibilities

The BECA is not responsible for establishing design concept(s), design criteria, design solutions, compliance with Codes, design or general construction scheduling, or construction management. The BECA may assist with problem-solving or resolving non-conformances or issues, but ultimately that responsibility resides with the General Contractor and the Prime Consulting Design Team. The BECA is not responsible for issuing change orders or other instructions to the field for corrective work.



APPENDIX A - AVAILABLE TEMPLATES & FORMS

The following templates and forms are available for reference and use as required. These templates and forms are meant to represent general guidelines and are not meant to be prescriptive or all inclusive and may be modified to suit as appropriate for the application.

The templates and forms may relate to both Whole Building Commissioning and Building Envelope Commissioning and can be accessed from the link provided. Templates are subject to continuous improvement development.

Commissioning Related Document Templates and Forms are included below. The intent is whenever possible to combine Building Envelope Commissioning and Whole Building Commissioning into one checklist/log/document:

- Stakeholder Questionnaire
- Owner Project Requirements (OPR)
- Commissioning Plan (Cx Plan)
- Commissioning (Cx) Issues and Resolutions Log
- Commissioning Report (Cx Report)
- Final BECx Report checklist



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