

APPENDIX L

BUILDING ENCLOSURE COMMISSIONING

PART 1 GENERAL

1.1 SUMMARY

- A. The design intent of the building enclosure is to provide exterior floor, wall, and roof assemblies which prevent uncontrolled air and water infiltration and include products and assemblies that are technically sound, durable and serviceable. This section includes requirements for non-structural commissioning of the building enclosure, including, but not limited to the following:
1. Below-grade construction, including foundation walls and slabs-on-grade.
 2. Above-grade construction, including: exterior wall materials and assemblies; steep-slope and low-slope roofing, outdoor plazas, planters and plaza paving systems and assemblies over occupied space, as well as glazed window, curtain wall and sloped glazing systems.
 3. Interface conditions (flashings, expansion joints, sealant) between each of the materials, components and systems that comprise the above and below-grade building exterior enclosure.
 4. Thermal and Moisture Protection standards to meet or exceed the City of Fort Collins Green Building Code.
- B. The purpose of the building enclosure commissioning (BECx) is to provide a process for independent, third-party verification that the installed performance of the building enclosure meets or exceeds the minimum performance requirements set forth by the Contract Documents for this project. The materials, components, systems, and assemblies that comprise the above and below-grade building exterior enclosure will be evaluated and tested as outlined in this Section, as well as in accordance with each of the technical Sections associated with the design and construction of the building enclosure.

1.2 RELATED DOCUMENTS AND SECTIONS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other General Requirements and Technical Specification Sections, apply to this Section.
1. Division 1 Section "Commissioning Plan & Specification"
 2. Division 1 Section "Sustainable Design Requirements" for specific requirements related to LEED Project Requirements.
 3. Division 4 Section "Unit Masonry Assemblies"
 4. Division 4 Section "Dimension Stone Cladding"
 5. Division 6 Section "Panel Sheathing"

6. Division 6 Section "Fiberglass Reinforced Paneling"
7. Division 7 Section "Self-Adhering Sheet Waterproofing"
8. Division 7 Section "Thermal Insulation"
9. Division 7 Section "Fluid Applied Membrane Air Barriers"
10. Division 7 Section "Composite Metal Wall Systems"
11. Division 7 Section "Thermoplastic Membrane Roofing"
12. Division 7 Section "Sheet Metal Flashing and Trim"
13. Division 7 Section "Joint Sealants"
14. Division 8 Section "Steel Doors and Frames"
15. Division 8 Section "Aluminum Entrances and Storefronts"
16. Division 8 Section "Glazed Aluminum Curtain Walls"
17. Division 8 Section "Aluminum Windows"
18. Division 8 Section "Glass and Glazing"
19. Division 9 Section "Gypsum Board Assemblies"

1.3 REFERENCE STANDARDS

- A. Section 502.4.3.1 of the 2009 International Energy Conservation Code as amended by the City of Fort Collins – "Design Requirements"
- B. City of Fort Collins Building Air Leakage Test Protocol
- C. ASHRAE NIBS Guideline 3 "Exterior Enclosure Technical Requirements for the Commissioning Process"
- D. U.S. Army Corps of Engineers "Air Leakage Test Protocol for Measuring Air Leakage in Buildings"
- E. ASTM E779 "Standard Test Method for Determining Air Leakage Rate by Fan Pressurization"
- F. ASTM E783 "Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors"
- G. ASTM E1105 "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"
- H. ASTM E1186 "Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems"
- I. ASTM E1827 "Standard Test Methods for Determining Air tightness of Buildings Using an Orifice Blower Door"

1.4 DEFINITIONS AND ABBREVIATIONS

- A. Architect: Architect-of-Record for this project
- B. Building Enclosure: The physical separator between the interior and exterior environments of a building. Typical building enclosure components include the base floor systems, below-grade wall systems, above-grade wall systems (including windows and doors), and the roof systems.
- C. Building Enclosure Commissioning (BECx): The process of inspecting and testing building components and assemblies to ensure the installed performance of the building enclosure meets or exceeds the minimum performance requirements set forth by the Contract Documents.
- D. Building Enclosure Commissioning Authority (BECxA): The Party retained by the Commissioning Authority which will manage the BECx process, develop and stipulate the BECx requirements, and validate that the components and assemblies are designed, constructed, and tested to meet requirements set forth in the in the Contract Documents.
- E. Building Enclosure Commissioning Plan (BECxP): Project-specific protocol developed by the BECxA, which outlines the BECx process for all related components and assemblies. This document will identify the Commissioning Team and include comprehensive checklists and general schedule of all tasks involved in the BECx, including design reviews, construction observations, mockup construction and testing, whole building air leakage testing, and technical reports that will be produced over the course of the Project.
- F. Building Enclosure Commissioning Report: The final deliverable from the BECx process, this document includes a full summary report with appropriate documentation including the following information: a narrative describing the BECx items and issues found, a summary and list of enclosure systems and components included in the commissioning program, a description of non-compliant conditions noted during site observations with follow up documentation on the means and methods to resolve, and summary results of building performance testing.
- G. Building Enclosure Commissioning Team: Owner and their consultants, Contractor, Architect, Commissioning Authority, Building Enclosure Commissioning Authority.
- H. Commissioning Authority (CxA): The Party responsible for coordinating and carrying out the entire scope of the commissioning process. The Commissioning Authority collaborates with the BECxA to accomplish the building enclosure commissioning.
- I. Contract Documents: Documents governing the responsibilities and relationships between Parties involved in the design and construction of this project, including

(but not limited to): Agreements/Contracts, Drawings and Specifications, Addenda, Change Orders, BECx Plan (for reference only).

- J. Construction Documents: Refers to the Contract Documents that dictate the details of construction.
- K. Contractor: As used herein, 'Contractor' is a general reference to the installing Party and can therefore refer to the General Contractor, Project Manager, subcontractors, or vendors as inferred by its usage.

1.5 BUILDING ENCLOSURE COMMISSIONING AUTHORITY REQUIREMENTS

- A. Current registered Professional Engineer, Licensed/Registered Architect, or a commissioning entity (Commissioning Authority) certified by The Building Commissioning Association (BCA) or AABC Commissioning Group (ACG).

Certification	Organization
CxA	ACG (AABC Commissioning Group)
CBCP	AEE (Association of Energy Engineers)
CPMP	ASHRAE (American Society of Heating Refrigeration and AC Engineers)
CCP	BCA (Building Commissioning Association)
CxAP or CAP	UWM (University of Wisconsin Madison)
CxM	UWM
GcxP or GCP	UWM

- B. A minimum 4 years of experience in the practices that encompass BECx-related consulting services, including all of the following:
 1. Performing architectural drawing and specification design peer reviews.
 2. Evaluating submittal compliance.
 3. Administering pre-design and pre-construction meetings.
 4. Performing/supervising relevant field performance and diagnostic testing.
 5. Evaluating as-built component/assembly compliance.
 6. Performing forensic evaluations of as-built construction.
- C. A minimum 4 years of direct experience in the commissioning of building envelope systems, with a minimum of 3 projects in commercial and institutional

buildings. Experience must include performing/supervising all field performance and diagnostic tests referenced in Part 3 of this Specification Section.

- D. Level I Certified Infrared Thermographer designation or greater by a nationally accredited certification institution.

1.6 BUILDING ENCLOSURE COMMISSIONING AUTHORITY SCOPE OF SERVICES / RESPONSIBILITIES

- A. CxA will engage a qualified BECxA to perform all consulting services, including design reviews, collaborative meetings, quality assurance observations, and field testing, unless specified otherwise.
- B. Prior to commencement of construction, develop a Building Envelope Commissioning Plan (BECxP) for this project, which outlines the BECx process for all related components and assemblies. This document will identify the Commissioning Team and include a comprehensive checklist and general schedule of all tasks involved in the BECx, with responsibilities assigned, including planning meetings, design reviews, construction observations, mockup construction and testing, fenestration testing, and whole building air leakage testing, and technical reports that will be produced over the course of the Project.
- C. During construction phase, deliverables to the CxA and Owner will include the following:
 - 1. Photograph-based quality assurance reports
 - 2. Technical memoranda
 - 3. Written recommendations for proposed solutions of deficiencies noted
 - 4. Checklists, completed by the Contractor, with annotation of deficiencies
 - 5. Submittals for all field testing to be performed
 - 6. Comprehensive technical reports for all field testing performed and witnessed at 50% DD, 50% CD, and 95% CD.
- D. Review project drawings and specifications at 50-percent and 100-percent design complete for constructability and conformance with respect to air, water, and vapor barriers of the exterior building enclosure. Prepare a written report along with redlined drawing sheets.
- E. Review and comment on submittals from the Contractor for compliance with the building enclosure requirements set forth in the Contract Documents. Note that the BECxA does not have the authority to accept or reject submittals.
- F. Schedule a pre-construction commissioning conference prior to start of the construction of the building enclosure, at a time convenient to the Owner, Contractor, and Architect. The BECxA will conduct the meeting to review commissioning responsibilities and personnel assignments.

1. Attendees: Authorized representatives of Owner, all Contractors whose work is relevant to the building enclosure, Commissioning Authority, Architect, and other concerned parties shall attend the conference. All participants at the conference shall be familiar with Project and authorized to conclude matters relating to commissioning.
 2. Agenda: Discuss items of significance that could affect progress including the following:
 - a. Building Enclosure Commissioning Plan and related specifications
 - b. Tentative construction schedule per Contractor
 - c. Phasing
 - d. Critical work sequencing
 - e. Designation of key personnel and their duties
 - f. Mockup construction and testing
 - g. Procedures for testing and inspecting
 - h. Submittal procedures
 - i. LEED requirements
 - j. Preparation of record documents
 - k. The process for correcting deficient work
 - l. Maintenance requirements to maintain enclosure
- G. Observe construction of building enclosure work and report progress and deficiencies. Provide a report of each site visit, including a list of observed deficiencies and discrepancies, to CxA, Owner and General Contractor.
- H. Per City of Fort Collins code commissioning requirements, inspect the air barrier assembly for continuity and integrity at the follow locations in the building prior to 5% completion of each:
- a. Roof-wall intersections
 - b. Fenestration flashing
 - c. Fenestration installation
 - d. Bottom of wall (wall-to-foundation connection)
 - e. Connection of dissimilar wall and roof assemblies
 - f. Isolation of interior rooms such as mechanical and paint rooms
 - g. Wall and roof penetrations
- I. Facilitate and perform mock-up field testing of exterior building envelope components and assemblies, as required by the Contract Documents. Document construction of commissioned components at the completion of mock-up testing and provide a technical report with this information to CxA and Owner.
- J. Participate (in person if conducted during BECxA observation of building enclosure work, or remotely if not) in periodic BECx meetings to review and discuss issues and concerns related to the building envelope noted by the Architect of Record, the CxA, BECx, and the Owner.

- K. Facilitate and perform field tests identified to be accomplished by the “Testing Agency” in the Sections identified in Part 3.

After all air barrier components are installed, facilitate and perform whole building air tightness testing in accordance with City of Fort Collins Building Air Leakage Test Protocol of 0.25 CFM/SF @ 75 PA. Testing shall consist of both performance and diagnostic evaluations. Document test results per City of Fort Collins Certification of Compliance – Building Air Leakage Test Results and provide to the CxA and Owner.

- L. Include the Building Enclosure Systems Manual provided by the BECxA as part of the Operations and Maintenance Manual. This Systems Manual includes the following items, as related to the building enclosure:

1. Identification of installed exterior enclosure components, assemblies, systems, and equipment.
2. Certificate of completion, certifying that exterior enclosure assemblies, systems, equipment and associated controls are complete and ready for testing.
3. As-built drawings, including a copy of all details and drawings that were installed as part of any addendums or change orders directives.
4. Project specifications, including all accepted product substitutions and any additional specifications as part of addendums or change order directives.
5. A copy of all accepted change orders.
6. A copy of all shop drawings with the Architect’s mark-ups, showing the as-built conditions.
7. A copy of all warranties, organized by product, and all product manufacturer’s letters indicating the product as appropriate to the use for the application installed at this project.
8. A master product list summarizing all products used on the project for construction of the building enclosure, organized by tabs in a binder, including the following:
 - a. Product name
 - b. Product manufacturer
 - c. Catalog or other applicable number for ordering
 - d. Manufacturer’s contact information, including the contact information for the technical representatives
 - e. Product color
 - f. Supplier contact information
 - g. Product installation instructions, including instructions supplied with any of the shop drawings
 - h. Manufacturer’s product maintenance guide
 - i. Manufacturer’s checklist for periodic review/maintenance plan
9. All submittals pertinent to BECx.

- M. The Building Enclosure Systems Manual shall be developed for each major building exterior enclosure system including, but not limited to:
 - 1. Roof systems (including parapets, penetrations, curbs, etc.)
 - 2. Skylights/sloped glazing
 - 3. Exterior wall systems (all types)
 - 4. Windows
 - 5. Doors
 - 6. Sealants
 - 7. Building expansion joint accessories (roof and wall)
 - 8. Flashings
 - 9. Shading devices
 - 10. Curtain walls/window walls, storefronts
 - 11. Below-grade waterproofing
 - 12. Planters and planted areas adjacent to building enclosure
 - 13. Floors (slab-on-grade, crawlspace, etc.)
 - 14. Any other special building enclosure system, equipment and controls.

- N. Conduct a maintenance and training orientation meeting/inspection with Contractor, CxA, Owner's representative, and building operations and maintenance staff. Review the Building Enclosure Systems Manual to ensure all parties understand expected performance levels and maintenance requirements of building enclosure components.

- O. Prepare BECxReport and deliver to CxA and Owner.

- P. Prepare and submit LEED documentation, if required in 018113 Sustainable Design Requirements, for an Innovation in Design Credit for BECx.

- Q. Building Enclosure Commissioning Authority is not authorized to:
 - 1. Release, revoke, alter or expand requirements of Contract Documents
 - 2. Approve or accept any portion of the work
 - 3. Revise construction drawings and specifications
 - 4. Perform any duties of the Contractor

1.7 CONTRACTOR RESPONSIBILITIES

- A. Furnish copies of all submittals, shop drawings, manufacturer's literature, installation instructions, maintenance information, schedules, warranties, or other information as requested. Note that it is the Architect and Contractor's responsibility to approve or reject submittals and shop drawings.

- B. Provide access to work, including scissor/boom lifts and/or scaffolding and coordinate scheduling with the BECxA to perform BECx tasks.

- C. Provide qualified personnel for assistance in completing the commissioning inspections and tests for elements of the building envelope.
- D. Construct negative pressure test chambers, as directed by the BECxA, used to accomplish ASTM E783 and E1105 field testing in Division 07 and 08.
- E. Provide a power and water source for completing the commissioning tests for elements of the building envelope.
- F. Submit a copy of the General Contractor's project and site specific Quality Assurance program to be implemented for construction for review prior to beginning of construction.
- G. Participate and ensure all subcontractors utilized for work on the building enclosure participate in the Preconstruction Meeting with the design and construction teams, Owner's representatives, CxA and BECxA.
- H. Complete and participate in the construction of on-site mock-ups including elements of the building exterior enclosure, as identified in individual sections of the specifications in Divisions 2 through 9.
- I. Provide personnel to be present and have a representative present from each trade and/or subcontractor associated with installing the systems during mock-up performance testing. Personnel who are to be completing work in the field are to be utilized to participate in the construction of on-site mockups of building enclosure assemblies as required by the Construction Documents, and to have a representative present during inspection and testing of mockups. If deficiencies are observed within the mockup, provide labor and materials to repair or reconstruct the mockup such that deficiencies do not exist and mockup passes field testing.
- J. Schedule and conduct periodic BECx meetings with a representative present from each trade and/or subcontractor to review and discuss issues and concerns related to the building envelope noted by the Architect of Record, the CxA, BECxA, and the Owner and what action will be taken to address the noted non-conformances. Maintain a summary of non-conformances and current status.
- K. Reimburse Owner for additional testing and inspections if building enclosure systems and mockups are not constructed per Construction Documents.
- L. Prepare the building envelope to be in the "Closed" position as identified in Specification 072726 and as directed by the BECxA for whole building Air Barrier Testing.

- M. If the building fails the Air Barrier Test specified in 072726, BECxA will perform diagnostics to identify deficiencies and sources of air leakage. Trades related to deficiencies shall provide labor and materials to adequately repair these areas.

1.8 ARCHITECT RESPONSIBILITIES

- A. Provide paper and electronic copies of project drawings and specifications to the BECxA.
 - 1. Clearly illustrate the continuous air barrier boundary on additional plan and section sheets, as required. Boundary to include integrated floor/slab, walls, and roof/ceiling assemblies.
 - 2. Clearly define air barrier materials and assemblies for each component on drawings and in related specifications. Specified air barrier materials and assemblies should meet the requirements set forth in applicable Divisions of the Specification.
 - 3. Provide surface area calculations for the air barrier boundary.
 - 4. Provide details illustrating integration of air barrier materials at all transitions (e.g., roof-to-wall, wall-to-floor, building expansion joints, exterior doors and windows, etc.).
- B. Provide written responses to design review comments from the CxA or other parties as requested.
- C. Attend pre-construction commissioning conference.
- D. Perform submittal review, construction observation, as-built drawing preparation, etc. as contracted.
- E. Coordinate resolution of system deficiencies identified during BECx according to contract documents.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

- A. Systems to be commissioned: Refer to the Related Documents and Sections identified in 1.2 for specific requirements. The systems and elements to be commissioned include, but are not limited to:
 - 1. Roof systems (including parapets, penetrations, curbs, etc.)
 - 2. Skylights/sloped glazing
 - 3. Exterior wall systems (all types)
 - 4. Windows
 - 5. Doors

6. Sealants
 7. Building expansion joint accessories (roof and wall)
 8. Flashings
 9. Shading devices
 10. Curtain walls/window walls, storefronts
 11. Below-grade waterproofing
 12. Floors (slab-on-grade, crawlspace, etc.)
 13. Any other special building enclosure system, equipment and controls.
- B. Contractors shall provide sufficient notice to the BECxA regarding their completion schedule for the mockup assemblies or envelope.
- C. Mockup Testing Requirements
1. Mockup tests will be performed by the BECxA per Contract Documents in order to verify component and assembly performance prior to commencing with construction or during the first phase of construction.
 2. Contractors shall provide sufficient notice to the BECxA regarding their completion schedule for the mockup assemblies or exterior enclosure systems. The BECxA will schedule field testing through the Contractor and CxA.
 3. If mockups do not pass initial testing, Contractor shall provide labor and materials to repair mockup until a successful test is achieved.
 4. Add an alternate to do testing on a partially complete building.
- D. Test Methods
1. The test methods listed below are included as reference to their respective Specification Sections. This is a summary of the field tests required by the Construction Documents.
 2. Section 074243 - COMPOSITE METAL WALL PANEL SYSTEMS
 - a. Construct mockup in the location and of the size as directed by the Architect
 - b. Test mockup in accordance with ASTM E1105 as specified in this Section.
 3. Section 084113 - ALUMINUM ENTRANCES AND STOREFRONTS
 - a. Construct mockup in the location and of the size as directed by the Architect.
 - b. Test mockup (stand-alone or installed) in accordance with ASTM E783 to the requirements set forth in the related specification section.
 - c. Test mockup (stand-alone or installed) in accordance with ASTM E1105 to the requirements set forth in the related specification section.
 4. Section 084413 – GLAZED ALUMINUM CURTAIN WALLS
 - a. Construct mockup in the location and of the size as directed by the Architect.

- b. Test mockup (stand-alone or installed) in accordance with ASTM E783 to the requirements set forth in the related specification section.
 - c. Test mockup (stand-alone or installed) in accordance with ASTM E1105 to the requirements set forth in the related specification section.
- 5. Section 085113 – ALUMINUM WINDOWS
 - a. Construct mockup in the location and of the size as directed by the Architect.
 - b. Test mockup in accordance with ASTM E783 to the requirements set forth in the related specification section.
 - c. Test mockup in accordance with ASTM E1105 to the requirements set forth in the related specification section.
- 6. Specification 014525 – WHOLE BUILDING AIR BARRIER TESTING
 - a. After all air barrier components have been installed, conduct whole building air barrier testing.
 - b. Test building in accordance with the City of Fort Collins Building Air Leakage Test Protocol. Accomplish both performance testing and diagnostic evaluation, as described in the Protocol for both pass and fail conditions.
- 7. Interface between parapet and roof.
- 8. Prioritize activities or testing that would provide the best return on investment and energy performance.