

SECTION 019115 – Building Enclosure Commissioning Requirements

Latest Update: 1.26.2026.

(Building Enclosure Commissioning Provider shall edit specifications and blue text in header to meet project requirements. This includes but is not limited to updating testing indicated in the specifications and adding any additional specifications that may be required by the project. Delete paragraphs not applicable to the project, and note some pertinent editor's comments in this section by the University. Turn off underlines)

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes the administrative requirements related to commissioning and includes the following:

1. Definitions
2. Related documents
3. Coordination
4. Quality control
5. Responsibilities
6. Applicable standards
7. Test equipment
8. Meetings
9. Reporting
10. Pre-functional checklists
11. In-situ testing
12. Documentation, non-conformance and approval of tests
13. Building enclosure mock-up (in-situ)
14. Repair and Protection
15. Training
16. Final BECx report

- B. This section shall be used in conjunction with section 019113 – General Commissioning Requirements.

1. Building Enclosure Commissioning (BECx) is an integral component of the overall Building Commissioning process. The final Building Enclosure Commissioning (BECx) Report shall be incorporated into the Final Commissioning Report as defined in Section 019113.

- C. Related Sections:

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|----|--------|-------------------------|
| 1. | 033000 | Cast-In-Place Concrete |
| 2. | 042000 | Unit Masonry |
| 3. | 044200 | Exterior Stone Cladding |

4.	061500	Exterior Architectural Woodwork
5.	070152	Operation and Maintenance of Thermal and Moisture Protection
6.	070543	Cladding Support System
7.	071326	Sheet Waterproofing
8.	071413	Hot Fluid Applied Rubberized Asphalt Waterproofing
9.	071616	Crystalline Waterproofing
10.	071800	Traffic Coating
11.	071900	Water Repellents
12.	072100	Thermal Insulation
13.	072726	Fluid-Applied Membrane Air Barrier
14.	074213	Metal Composite Material Wall Panels
15.	074229	Terra-Cotta Wall Panels
16.	075200	Modified Bituminous Membrane Roofing
17.	076200	Sheet Metal Flashing and Trim
18.	077129	Manufactured Roof Expansion Joint
19.	077273	Vegetated Roof System
20.	079100	Preformed Joint Seals
21.	079200	Joint Sealants
22.	079513	Exterior Expansion Joint Cover Assemblies
23.	084126	All-Glass Entrances
24.	084413	Glazed Aluminum Curtain Walls
25.	084426	Structural Glass Facades
26.	088000	Glazing
27.	089119	Fixed Louvers
28.	099600	High-Performance Coatings
29.	099672	Fluid-Applied Insulation Coatings

1.2 DEFINITIONS

- A. Air Barrier Envelope: The continuous boundary separating indoor and outdoor air. It consists of integrated assemblies, components, and accessories designed to prevent airflow across the environmental separator, encompassing the top, bottom, and all sides of the structure.
- B. Air Leakage Rate: The volume of air infiltration or exfiltration through the building envelope over time. This is measured as the airflow rate per unit of surface area at a specified differential pressure.
- C. Basis of Design (BOD): A formal document developed by the design team outlining the technical concepts, assumptions, calculations, and product selections required to meet the Owner's Project Requirements (OPR).
- D. Bias Pressure: This is the natural differential pressure between a sealed envelope and the outdoors when not artificially pressurized. It includes fixed static offsets (e.g., stack effect or HVAC) and fluctuating pressures (e.g., wind or elevator movement); multiple readings are typically averaged for accuracy.

- E. Blower Door: A diagnostic apparatus used to pressurize or depressurize a building to quantify envelope air leakage. It consists of a calibrated fan mounted in an exterior door frame using an airtight fabric or panel system to measure airflow.
- F. Building Enclosure (or envelope): The collective materials and systems that serve as an environmental separator between the interior and exterior, or between interior zones with different environmental requirements. The terms "enclosure" and "envelope" are used interchangeably.
- G. Building Enclosure Commissioning (BECx): Technical service provided on behalf of UMB to provide a quality-focused process for enhancing the performance of the building enclosure by validating the design phase and verifying during the construction phase that the performance of the building enclosure materials, components, assemblies, and systems are designed and installed to meet the Owner's Project Requirements (OPR).
- H. Building Enclosure Commissioning Provider (BECxP): An entity that functions as part of the overall commissioning team and is responsible for validating the design phase and verifying during the construction phase that the performance of the building enclosure materials, components, assemblies, and systems are designed and installed to meet the Owner's Project Requirements (OPR).
- I. Construction Phase: The period of a project following the award of construction contract to project completion.
- J. Design Phase: The period of the project delivery process when a design supporting the Owner's Project Requirements is developed and translated into contract documents.
- K. Deficiency: A condition in the installation or function of a component, or assembly that is not in compliance with the contract documents, that is, does not perform properly or is not complying with the Owner's Project Requirements.
- L. Issues Log: This is a log that is maintained and updated by the BECxP that includes all deficiency items that relate to the BECx activities, including a summary description of each deficiency, including a photograph where appropriate. The log shall include the date each deficiency item was first documented, that appropriate party responsible for remedial action, the date corrective action was performed, and a brief summary of the remediation.
- M. Environmental separator: The parts of a building that separate the controlled interior environment from the uncontrolled exterior environment, or that separate spaces within a building that have dissimilar environments. The term "environmental separator" is also known as the control layer.
- N. First Installation Mock Up: The first full production-quality installation of a specific enclosure assembly or system, constructed as part of the actual building, and designated as a formal quality-control and performance verification benchmark before repetitive work proceeds. It is a construction-phase control mechanism, not a design-phase test assembly.

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- O. Functional Performance Test (FPT): A systematic process to verify that controls and other elements of the building project are capable of and configured to operate or perform as required.
- P. In-situ Mock Up: A full-scale, field-constructed assembly of building enclosure components built on the actual project site, using the actual materials, trades, sequencing, and installation methods that will be used in the permanent construction. It is a performance verification tool, not merely a visual or aesthetic sample.
- Q. Laboratory Mock Up: A full-scale or large-scale enclosure assembly constructed in a controlled laboratory environment for the purpose of performance testing, system validation, and design verification prior to field construction.
- R. Owner's Project Requirements (OPR): A document that details the stakeholders' requirements for the project and expectations for how it will be used and operated.
- S. Pre-functional Checklist: A quality control document used to verify that enclosure materials and assemblies are correctly installed, set up, and ready for formal performance testing.
- T. Pressure Test: A generic term for a test in which the envelope is either pressurized or depressurized with respect to the outdoors.
- U. Negative Pressure Test (Depressurized Test): A test wherein air inside the envelope is drawn to the outdoors. This places the envelope at a lower (negative) pressure with respect to the outdoors.
- V. Positive Pressure Test (Pressurized Test): A test wherein outdoor air is pushed into the envelope. This air movement places the envelope at a higher (positive) pressure with respect to the outdoors.
- W. Abbreviations: The following are common abbreviations used in the Building Enclosure Commissioning Specification:
1. A/E - Architect and Engineers
 2. BECxP – Building Enclosure Commissioning Provider
 3. BECx Plan – Building Enclosure Commissioning Plan
 4. BOD – Basis of Design
 5. FPT - Functional Performance Test
 6. CM/GC - Construction Manager/General Contractor <Edit for Project>
 7. OPR – Owner's Project Requirements
 8. PM - Project Manager (University)
 9. Subs - Subcontractors to the General Contractor
 10. ABAA – Air Barrier Association of America
 11. ASTM – American Society for Testing and Materials

1.3 RELATED DOCUMENTS

- A. Drawings and general provisions of the contract, including general and supplementary conditions and other Division 01 specification sections, apply to this section.
- B. Individual building enclosure specification sections: Individual building enclosure technical sections stipulated requirements for material testing, and warranties for the material, product or assembly specified in this section.
- C. Building Enclosure Testing Work Plan:
 - 1. For each building enclosure test to be performed, submit the following not less than <XX> calendar days prior to commencement of testing, steps to be taken by the test technician to accomplish the required testing.
 - a. Memorandum of test procedure
 - 1) Proposed dates for conducting the tests.
 - 2) Submit detailed test procedures prior to the test. Provide a plan view showing proposed locations to install equipment.
 - b. Test equipment to be used.
 - c. Scaffolding, scissor lifts, power, electrical extension cords, duct tape, plastic sheeting and other contractor's support equipment required to perform all tests.

1.4 COORDINATION

- A. Refer to Section 019113 General Commissioning Requirements for requirements pertaining to coordination during the commissioning process. Coordinate with commissioning provider in accordance with the commissioning specifications and in accordance with the commissioning plan to schedule inspections as required to support the commissioning process.
- B. Commissioning Team:
 - 1. Building Enclosure Commissioning Provider:
 - a. Project Manager
 - b. Project Technicians
 - 2. Building Enclosure Specialist
 - a. Project Manager
 - b. Project Technicians
 - 3. Construction Manager (CM) / General Contractor (GC):
 - a. Project Manager
 - b. Enclosure Subcontractors
 - 4. Design team:
 - a. Architect/Engineer of Record
 - 1) Project Manager
 - 2) Project Architect / Engineer
 - 3) Design staff
 - 5. Owner Representative(s)

6. Operation and Maintenance team:
 - a. Facility Manager
 - b. Staff
- C. Management: BECxP directs and coordinates the commissioning activities to owner's representatives. All members work together to fulfill their contracted responsibilities and meet the objectives of the contract documents.
- D. Scheduling: BECxP will work with Construction Manager (CM) and/or General Contractor (GC) according to established protocols to schedule commissioning activities. The BECxP will provide sufficient notice to the CM/GC for scheduling commissioning activities. The CM/GC will integrate all commissioning activities into the master schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.
 1. BECxP will provide BECx Plan that includes the schedule. As Construction progresses more detailed schedules are developed by the BECxP.
- E. Functional Testing Coordination:
 1. BECxP will provide test protocol development that includes testing methods, parameters, pass/fail criteria.
 2. BECxP will coordinate with the CM/GC and their building enclosure subcontractors to ensure testing is performed after assembly installation and after all materials have cured in accordance with the manufacturer's installation requirements. Test assemblies shall not be sealed, concealed, or covered by materials outside the testing scope.

1.5 QUALITY CONTROL

- A. Qualifications:
 1. BECxP qualifications:
 - a. The BECxP shall be an independent, third-party entity directly engaged by the owner.
 - b. Professional certification: BECxP shall obtain current certification as a Building Commissioning Process Provider (BECxP) or Accredited Commissioning Authority + Building Enclosure (CxA+BE) as awarded by the University of Wisconsin-Madison, or approved equivalent certification such as the CBECxP as awarded by IIBEC.
 - c. Experience: A minimum of five (5) years of demonstrated experience in building science, enclosure design, and field performance testing.
 2. Field Testing Personnel qualifications: Testing technicians performing field testing shall hold relevant certifications for their specific tasks, such as ABAA (Air Barrier Association of America) Certified Air Barrier Specialist for air barrier inspections.
 3. Laboratory Testing Agency qualifications: The laboratory must hold active accreditations from recognized bodies to prove they maintain a rigorous quality

- management system, such as ISO/IEC 17025, ASTM E329, FGIA (Fenestration and Glazing Industry Alliance) Laboratory Accreditation.
4. Thermography Personnel Qualifications: Personnel Performing thermographic investigations shall be certified in accordance with ASNT SNT-TC-1A or ISO 18436-7, minimum Level 1 certification for data acquisition and Level II for interpretation and reporting.
 5. Building Enclosure Specialist Qualifications: The Building Enclosure Specialist shall have a minimum of five (5) years documented experience in the design, inspection, testing, and evaluation of building enclosure systems similar in scope and complexity to the Project.

1.6 SUBMITTALS

- A. Basis of Design (BOD): Refer to Section 019113 General Commissioning Requirements. BECxP shall review BOD and verify for Owner's Project Requirements (OPR) compliance.
- B. Owner's Project Requirements (OPR) : The BECxP shall assist the Owner in initiating, developing, and documenting the OPR. The BECxP shall gather input from the Owner, design team, and facility staff to define specific building enclosure performance criteria, including energy efficiency, durability, air and water leakage performance, constructability, and maintenance expectations. The BECxP shall continuously update and refine the OPR throughout the project lifecycle as changes occur, ensuring that design and construction remain aligned with the Owner's objectives.
- C. Building Enclosure Commissioning Plan (BECx Plan): The BECxP shall develop the initial BECx Plan during the pre-design phase to define the project's commissioning scope and framework. The BECx Plan shall establish procedures to verify that the building enclosure complies with the Owner's Project Requirements (OPR) and performance objectives. The plan shall include detailed scheduling and phasing coordination, communication and reporting protocols, documentation requirements, and clearly defined roles and responsibilities for all BECx team members. The BECxP shall update and maintain the BECx Plan throughout the project as it progresses to reflect changes in scope, design, and construction.
- D. BECx Issues Log: The BECxP shall establish the format and management protocol for the issues log and document detailed descriptions of all design, installation, and performance deficiencies that deviate from the Owner's Project Requirements (OPR). The BECxP shall assign and track responsible parties for each issue, monitor response and corrective action timelines, and coordinate resolution. Upon completion of corrective actions, the BECxP shall verify compliance and formally close each item in the issues log.
- E. BECx Specifications: The BECxP shall develop project-specific Building Enclosure Commissioning (BECx) specifications based on the UMB Master Specification, formatted for inclusion in the Project Manual. The specification shall include a comprehensive test matrix identifying the enclosure assemblies to be tested, along with the applicable test methods, standards, and acceptance criteria for each test.

- F. Operation and Maintenance Manuals: The BECxP shall provide operation and maintenance manuals, that includes manufacturer maintenance instructions and required care procedures for the enclosure system, preventive maintenance procedures and schedules, warranties and any warranty maintenance conditions.
- G. Final BECx Report: The BECxP shall consolidate all enclosure commissioning activities into a single coherent record, including design review comments and resolutions, submittal reviews, site observation reports, test plans and results, issues log, operating and maintenance manuals for enclosure system.

1.7 RESPONSIBILITIES

- A. The responsibilities of all parties involved in the commissioning process and Building Enclosure Commissioning (BECx) process are defined in this section.
- B. Design Team: Architect / Engineer:
 - 1. Pre-Design Phase:
 - a. Review Owner's Project Requirements (OPR).
 - 2. Design-Phase:
 - a. Based on Owner's Project Requirements (OPR), develop Basis of Design (BOD).
 - b. Develop design packages and construction documents.
 - 3. Pre-Construction Phase:
 - a. Attend BECx construction kickoff meeting.
 - b. Provide input to BECx Plan.
 - c. Review submittals and respond to RFIs.
 - d. Review and respond to BECxP's comments on submittals, shop drawings, and RFIs.
 - 4. Construction Phase:
 - a. Attend BECx meetings.
 - b. Review submittals and RFIs.
 - c. Review and respond to site observation reports provided by BECxP.
 - d. Review resolutions and action items provided by BECxP.
 - 5. Closeout, Occupancy and Operations Phase:
 - a. Review the Updated Owner's Project Requirements (OPR) and Operation and Maintenance Manuals.
- C. BECx Provider (BECxP):
 - 1. Pre-Design Phase:
 - a. Prepare and attend BECx kick-off meeting.
 - b. Provide assistance with Owner's Project Requirements (OPR) and BECx budget and scope.
 - c. Develop issues and resolution log format and protocols.
 - d. Develop initial BECx Plan.
 - 2. Design-Phase:

- a. Conduct design phase BECx kick-off meeting.
 - b. Review Basis of Design (BOD).
 - c. Update BECx plan and issues to the project team.
 - d. Develop and finalize draft BECx specifications and test plan.
 - e. Prepare and provide design checklists.
 - f. Review design packages and conduct integration meetings.
 - g. Perform BECx focused reviews.
 3. Pre-Construction Phase:
 - a. Conduct BECx construction kickoff meeting.
 - b. Update BECx Plan.
 - c. Review and provide technical assistance on submittals, RFIs, and shop drawings.
 - d. Observe Performance Mock Up (PMU) construction and testing.
 - e. Attend pre-installation meetings.
 - f. Review QA/QC program checklists from CM/GC.
 - g. Develop and update BECx issues log.
 4. Construction Phase:
 - a. Conduct BECx meetings in construction phase.
 - b. Conduct site observations.
 - c. Continue updating BECx issues log.
 - d. Observe functional performance tests.
 - e. Assist team with resolution of action items.
 - f. Review project turnover documents from CM/GC.
 - g. Review Operation and Maintenance Manuals from CM/GC.
 - h. Prepare BECx report.
 5. Closeout, Occupancy and Operations Phase:
 - a. Verify operation and maintenance training.
 - b. Perform 10 month warranty review.
 - c. Update Owner's Project Requirements (OPR) and Operation and Maintenance Manuals.
 - d. Compile and issue final BECx report.
 - e. Coordinate follow-up testing if needed.
- D. Construction Manager (CM) / General Contractor (GC):
1. Pre-Construction Phase:
 - a. Attend BECx construction kickoff meeting.
 - b. Provide input to BECx Plan and review BECx Plan.
 - c. Provide construction schedule.
 - d. Submit enclosure submittals.
 - e. Coordinate and construct performance mock up.
 - f. Conduct pre-installation meetings.
 - g. Develop QA/QC program checklists.
 2. Construction Phase:
 - a. Attend BECx meetings.
 - b. Review and respond to site observation reports that provided by BECxP.
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- c. Coordinate and provide support to enclosures Functional Performance Tests (FPT).
 - d. Conduct required enclosure testing.
 - e. Assemble project turnover documents.
 - f. Compile Operation and Maintenance Manual.
 - g. Review BECx report.
 - E. Owner / Owner's representatives
 - 1. Pre-Design Phase:
 - a. Select qualified BECxP.
 - b. Develop BECx scope.
 - c. Review Owner's Project Requirements (OPR).
 - d. Review initial BECx plan.
 - 2. Design-Phase:
 - a. Review Basis of Design (BOD).
 - b. Attend design package review and integration meetings.
 - c. Review BECx specifications and test plan.
 - 3. Pre-Construction Phase:
 - a. Attend BECx construction kickoff meeting.
 - b. Review BECx Plan.
 - 4. Construction Phase:
 - a. Attend BECx meetings.
 - b. Review site observation reports.
 - c. Adjudicate identified BECx action items.
 - d. Review project turnover documents.
 - e. Review Operation and Maintenance Manual.
 - f. Review BECx report.
 - 5. Closeout, Occupancy and Operations Phase:
 - a. Conduct occupancy and operations planning meeting.
 - b. Collect O&M staff and occupant's feedback.
- 1.8 APPLICABLE STANDARDS
- A. NIBS Guidelines 3-2012, "Exterior Enclosure Technical Requirements for the Commissioning Process".
 - B. ASTM E 2813, "Standard Practice for Building Enclosure Commissioning".
 - C. ASTM E 2947, "Standard Guide for Building Enclosure Commissioning".
 - D. ASHRAE Standard 202-2018 (or latest adopted edition), "Commissioning Process for Buildings and Systems".
 - E. ASHRAE Guideline 0-2019 (or latest adopted edition)– "The Commissioning Process".
 - F. Reference standards as identified in the test plan.
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- G. Current LEED requirements.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. Provide all equipment necessary to perform testing of systems and components included in the commissioning scope. All testing instruments shall be of appropriate type, quality, and accuracy to measure system performance within the specified tolerances.
- B. Pressure Test Equipment
 - 1. Each airflow measurement system, including blower door fans and trailer mounted fan assemblies shall be calibrated within the last five (5) years. Equipment shall demonstrate measurement accuracy within 5% of the recorded airflow reading.
- C. The thermal imaging camera used for thermographic testing shall meet the following minimum performance criteria:
 - 1. Thermal sensitivity (NETD): $\leq \pm 0.1^{\circ}\text{C}$ at 30°C ($\leq 0.18^{\circ}\text{F}$ at 86°F)
 - 2. Operating spectral range: 2–15 micrometers
 - 3. IR image resolution: minimum 320×240 pixels
 - 4. Integrated image capture and storage capability
 - 5. Ability to export individual still-frame thermal images in digital format
 - 6. Compatibility with electronic thermographic investigation reports, including image insertion and documentation

PART 3 - EXECUTION

3.1 MEETINGS

- A. Attend all meetings in accordance with 019113 General Commissioning Requirements.
- B. The CM/GC shall provide timely updates to the construction schedule to ensure the BECxP has the information necessary to plan and execute the commissioning process efficiently. The CM/GC shall promptly notify the Owner or Owner's Representative of any anticipated construction delays that may impact commissioning activities, whether such activities have been scheduled or not yet performed.
- C. BECx Kick-Off Meeting:
 - 1. Clarify the Owner's Project Requirements (OPR) for the building enclosure and define the methods for verifying compliance.
 - 2. Review the draft BECx plan, including scope, testing strategy, and documentation requirements.
- D. Design Phase BECx Meeting:

1. Verify that the enclosure design (SD/DD/CD) aligns with the OPR and Basis of Design (BOD) to achieve the intended performance.
2. Review and refine the BECx plan and project-specific BECx specifications, including scope, testing, mock-ups, and documentation requirements
3. Identify and address enclosure risks and coordination gaps early in the design and planning process.

E. BECx Construction Kick-Off Meeting:

1. Translate the BECx plan and contract requirements into actionable construction expectations, identifying critical details, required tests, and procedures for documenting and resolving issues.
2. Coordinate schedules, sequencing, and site access for mock-ups, pre-installation meetings, field observations, and performance testing of building enclosure systems.
3. Clarify roles and communication protocols among the CM/GC, building enclosure subcontractors, BECxP, A/E, and owner representatives.

F. Construction Phase BECx Meeting:

1. Participate periodically during active enclosure work, addressing coordination, deficiency resolution, and planning matters during these meetings.

G. Occupancy and Operations Planning Meeting:

1. Establish an envelope operations and maintenance (O&M) strategy to preserve long-term performance and durability.
2. Define facilities staff training, documentation, and responsibilities to ensure early identification, reporting, and response to building enclosure issues.
3. Set post-occupancy performance expectations, including scheduled reviews, warranty inspections, and seasonal or targeted follow-up testing as required.

3.2 REPORTING

- A. Prepare and maintain the BECx Plan, updating it at major design and construction milestones, and re-issue to the project team.
- B. Establish, maintain, and regularly distribute the issues log, documenting the status of all enclosure-related items.
- C. Prepare design review reports for each required submission, capturing comments, risks, and recommended corrective actions. Back-check and re-issue updated reports after the design team responds, clearly identifying items that are resolved, revised, or remain open.
- D. Issue field observation reports after each enclosure site visit, including date, areas observed, photos, non-conforming work, and recommended actions.

- E. Review and comment on enclosure-related submittals, shop drawings, RFIs, and change orders, documenting comments in a format coordinated with the design team and CM/GC.
- F. Review construction checklists prepared by the CM/GC and report deficiencies or trends that may affect enclosure performance.
- G. Coordinate test plans and review field test reports provided by the testing agent.
- H. Compile the operation and maintenance manual for the building enclosure.
- I. Provide a BECx report at substantial completion and update the final BECx report following the 10-month warranty review.

3.3 COMMISSIONING SITE OBSERVATION

- A. The BECxP will conduct periodic site visits to monitor work progress and evaluate compliance with the Contract Documents, OPR, and industry standards. The Contractor shall coordinate access for the BECxP to review the work.
 - 1. The BECxP will identify noncompliant work, report findings to the CM/GC and Architect of Record (AOR), and provide a summary report of observations. The summary report will include a list of noncompliant items, serving as an ongoing construction issues log updated after each site visit. The A/E shall review all noncompliant items and provide directions for corrective action.
 - 2. The Contractor shall notify the A/E and BECxP immediately after completing any remedial work and before covering the work. Photographic documentation of remedied conditions is acceptable only if previously approved by the A/E and BECxP.
- B. The BECxP shall perform site observations at intervals sufficient to observe critical enclosure installations and transitions before concealment.
 - 1. Minimum observation milestones shall include:
 - a. Waterproofing system installation, including flashings and terminations.
 - b. Air barrier installation, including continuity at penetrations and transitions.
 - c. Fenestration installation, including flashing and integration with air/water barriers.
 - d. Sealant installation, including joint substrate conditions and tooling.
 - e. Building expansion joints, including continuity of air, water, and vapor barrier across movement joints.
 - f. Roofing installation, including terminations, penetrations, and field seams.
 - g. Final enclosure completion, verifying all interfaces and transitions are complete.
 - 2. Additional observations shall be performed when deficiencies or recurring installation issues are identified.
- C. The CM/GC shall provide minimum 72-hour notice prior to concealment of critical enclosure assemblies requiring observation by the BECxP.

3.4 PREFUNCTIONAL CHECKLISTS

- A. Development of Test Procedures: The BECxP shall develop specific test procedures and forms to verify and document the proper operation of each assembly. Subcontractors or vendors responsible for executing a test shall provide limited assistance to the BECxP, such as answering questions regarding equipment, operation, and sequences. Prior to test execution, the BECxP shall provide the procedures to the Sub(s) for review of feasibility, safety, equipment requirements, and warranty protection. The BECxP may submit procedures to the A/E for review if requested. Representative test formats and examples (not specific to this project) are included at the end of this Section.
- B. Coordination and Scheduling: Subs shall provide the BECxP with sufficient notice of the completion schedule for prefunctional checklists of all assemblies. The BECxP will coordinate functional performance test scheduling with the CM and affected Subs, and shall direct, witness, and document the testing. Subs are responsible for executing the tests.
- C. The BECxP will recommend solutions for issues identified during testing; however, responsibility for correcting, resolving, and retesting problems rests with the CM/GC, Subs, and A/E.
- D. Prefunctional Checklist:

TASKS	RESPONSIBLE	ASSISTANCE	DELIVERABLE	SCHEDULE MILESTONE
Submittals and Shop Drawings	GC		Approved Shop Drawings and Submittals	Prior to start of construction of every enclosure related system
In-place mock-ups	GC		Initial Installation of new assemblies at locations determined by BECxP, BE, and A/E	Prior to proceeding with complete installation of new assemblies
Sealant compatibility and adhesion tests ASTM C 1521	MFG	GC	Written test report and approval letter	Prior to the installation of sealant at each substrate type on the project, (usually on the mock up)
Waterproofing and Air Barrier Adhesion Testing	MFG	GC	Written test report and approval letter	Prior to installation of systems (usually on the mock up)
Site Inspections	A/E, BECxP	GC	Site Visit Report	Periodically during construction

1. Abbreviations:
- GC – General Contractor
 - MFG – Manufacturer
 - A/E – Architect / Engineer
 - BECxP – Building Enclosure Commissioning Provider

3.5 IN-SITU TESTING

- A. General Testing Requirements

1. Testing locations shall be selected by the BECxP and Architect of Record (AOR).
2. Additional testing may be required where deficiencies are identified.
3. Deficiencies identified during testing shall be corrected and retested at no additional cost to the owner.

B. Whole Building Airtightness Testing

1. Whole building airtightness testing shall be performed in accordance with the following test methods, as determined by the testing agency based on building size and configuration:
 - a. ASTM E779 for single-zone buildings, with strict weather limitations, or
 - b. ASTM E1827 for single-zone buildings using an orifice blower door, or
 - c. ASTM E3158 for large or multizone buildings.
2. The Maximum allowable air leakage rate shall not exceed 0.25 cfm/sf of total enclosure area at 0.3 in.w.g. (75 Pa), unless otherwise required by the Owner's Project Requirements (OPR) or applicable energy code.

Building Enclosure System or Component	Spec Section	Specified Test Standard	BECx Observation Required	Frequency of Testing	Failure Criteria
Whole Building		ASTM E779, or ASTM E 1827, or ASTM E3158 Building Airtightness Testing	YES	1 test	0.25 cfm/sf @ 0.3 in.w.g. (75Pa)
Whole Building		ASTM C 1060 Thermography Testing	YES	To be performed in conjunction with ASTM E 783 (Diagnostic)	
Whole Building		ASTM E 1186	YES	To be performed in conjunction with ASTM E 783 (Diagnostic)	

Building Enclosure System or Component	Spec Section	Specified Test Standard	BECx Observation Required	Frequency of Testing	Failure Criteria
Glazed Aluminum Curtain Walls	084413	ASTM E 783 (Air Leakage Volume test)	YES	6 tests (1 at mock up, 2 at 5%, 2 at 50%, and 1 at 90% completion)	0.06 cfm/sf @1.57 psf. If failure occurs; conduct 2 additional tests
Glazed Aluminum Curtain Walls	084413	ASTM E 1105 (Water Penetration test)	YES	6 tests (1 at mock up, 2 at 5%, 2 at 50%, and 1 at 90% completion)	No leakage on any interior surfaces or any part of the assembly intended to be a dry zone if failure occurs; conduct 2 additional tests
Glazed Aluminum Curtain Walls	084413	AAMA 501.1 (Dynamic Water Penetration)	YES	6 tests before installation of interior finishes	No leakage on any interior surfaces or any part of the assembly intended to be a dry zone if failure occurs; conduct 2 additional tests

Building Enclosure System or Component	Spec Section	Specified Test Standard	BECx Observation Required	Frequency of Testing	Failure Criteria
Glazed Aluminum Curtain Walls	084413	AAMA 501.2 Water-Spray Test	YES	3 tests (2% of the total mullion length) on separate units along head, sill and intermediate mullion after completion of curtain wall installation	If testing reveals consistent deficiencies, test 100 percent of assembly, remediate deficient areas, and retest.
Structural Glass Facades	084426	AAMA 501.2 Water-Spray Test	YES		
Sheet Waterproofing	071326	ASTM D 4541 (Field Adhesion Testing)	YES	1 test for each 1,000 square feet	
Hot Fluid-Applied Waterproofing (before installation of overburden)	071413	ASTM D 7877 (Electronic Leak Detection)	YES	1 test for each roof installation	
Hot Fluid-Applied Waterproofing (before installation of overburden)	071413	ASTM D 4263 (Concrete Moisture Test)	YES	1 test for each roof installation	
Hot Fluid-Applied Waterproofing (before installation of overburden)	071413	ASTM D 5957 (Flood Testing)	YES	1 test for each roof installation	

Building Enclosure System or Component	Spec Section	Specified Test Standard	BECx Observation Required	Frequency of Testing	Failure Criteria
Hot Fluid-Applied Waterproofing (before installation of overburden)	071413	Membrane Thickness Test	YES	Membrane Thickness Testing distributed throughout installation at testing frequency of 1 test/100 sq.ft.	
Hot Fluid-Applied Waterproofing	071413	Adhesion Testing (qualitative pull adhesion testing)	YES		
Under-slab Vapor Retarders	072616	Inspections	YES		
Modified Bitumen Sheet Air Barriers	072713	ASTM C 1193 or ASTM C 794 Adhesion Field Test	NO	preconstruction field-application testing	
Fluid-Applied Membrane Air Barriers	072726	Inspections ASTM 1186 & ASTM E 783 Air-Leakage Testing ABAA T0002	YES		0.04 cfm/sf @1.57 psf.
2-ply modified bitumen roof	075423	ASTM D 7877 (Electronic Leak Detection) ASTM C 1153 (Infrared Testing)	YES	1 test for each roof installation	

Building Enclosure System or Component	Spec Section	Specified Test Standard	BECx Observation Required	Frequency of Testing	Failure Criteria
Joint Sealants	079200	ASTM C 1521, Method A (Field Adhesion Testing)	NO	10 tests for the first 1000 feet of joint length, 1 test for each 1,000 feet of joint length	Water penetration past the primary seal
Exterior Expansion Joint Cover Assemblies	079513	AAMA 501.2 Water-Spray Test	YES		

3.6 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

- A. Documentation: The BECxP shall witness and document the results of all performance tests using the procedural forms developed for each test. Prior to testing, these forms shall be provided to the CM/GC for review and approval, and to the Subs for review. Completed forms will be included in the turnover documents.
- B. Non-Conformance:
1. The BECxP shall record all test results on the applicable procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the CM.
 2. Minor deficiencies may be corrected during testing at the discretion of the BECxP. Such corrections and resolutions shall be documented on the procedure form.
 3. Testing shall be conducted efficiently to minimize delays while maintaining full compliance with specified procedures and acceptance criteria. The BECxP shall not overlook deficient work or relax acceptance criteria to meet schedule or cost objectives, unless directed by the owner.
 4. As tests progress and a deficiency is identified, the BECxP shall discuss the issue with the executing GC.
 - a. When there is no dispute on the deficiency and the Sub accepts responsibility to correct it:
 - 1) The BECxP documents the deficiency and the Sub's corrective response. Testing proceeds to the next item. The Sub corrects the deficiency at no cost to the Owner, signs the statement of correction on the non-compliance form, and returns it to the BECxP.
 - 2) The BECxP reschedules and repeats the test.
 - b. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:

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- 1) Document the deficiency and the Sub's response on the nonconformance form; copies provided to the CM/GC and the responsible Sub representative.
 - 2) Resolve at the lowest management level possible, involving other parties as needed. Final interpretive authority rests with the A/E; final acceptance authority rests with the owner.
 - 3) The BECxP documents the resolution process.
 - 4) Once resolved, the responsible party corrects the deficiency, signs the statement of correction, and submits it to the BECxP. The BECxP reschedules and repeats the test until satisfactory performance is achieved.
5. The CM/GC shall provide written updates to the BECxP, A/E, and owner's representatives at least as frequently as commissioning meetings are scheduled, addressing the status of each outstanding discrepancy, including explanations of disagreements and proposed resolutions.
 6. The BECxP shall retain all original non-conformance forms until project completion.
 7. Any retesting required by a CM/GC shall not constitute a valid basis for a delay claim or time extension by the prime contractor.
- C. Approval: The BECxP shall note satisfactory demonstration of each function on the test form. Formal approval of functional performance tests occurs later, following review by the BECxP and, if necessary, the owner. The BECxP shall recommend test acceptance to the owner. Final approval is provided by the owner through signature on the test document.
- 3.7 BUILDING ENCLOSURE MOCK-UP (IN-SITU)
- A. General: Mock-ups are essential to verify that building enclosure construction meets contract requirements and the facility's performance needs. They allow inspection and validation of materials, installation techniques, and system integrity before components are installed on the building. Mock-ups must be successfully evaluated and approved prior to field installation.
- B. Mock-Up Evaluation Program: The Architect of Record (AOR) shall assist the Contractor responsible for assembling mock-ups in developing a detailed mock-up evaluation program. The AOR's primary role is to ensure a written plan exists to facilitate proper completion of procedures. Subs responsible for mock-up assembly and testing are identified during the commissioning scoping meeting.
1. The BECxP meets with the installing Subs to review the need for mock-ups of specific enclosure areas and configurations, including requirements and responsibility for each.
 2. Subs develop procedures for each mock-up, detailing materials, installation techniques, inspections, and testing requirements. Procedures are submitted to the BECxP for review and approval.
 3. The BECxP reviews and approves the procedures and documentation format, noting any additional procedures required.

C. Execution of Mock-Up Program:

1. Once approved, mock-up assembly may begin under the direction and execution of the responsible Sub or vendor.
2. At least four weeks prior to mock-up completion, Subs and vendors shall schedule the evaluation with the CM/GC and BECxP.
3. The BECxP shall inspect each mock-up and observe required testing, which is performed by the installing contractor.
4. The BECxP shall document inspection and testing results, including any deficiencies, and submit a report to the owner.

D. Deficiencies, Non-Conformance and Approval of Mock-Ups

1. Subs shall list any outstanding items from the initial mock-up inspection and testing on the procedures form or an attached sheet and provide it to the BECxP within two days of test completion.
2. The BECxP reviews the report and issues either a non-compliance report or an approval form to the Sub or CM/GC. The BECxP coordinates with Subs and vendors to correct and retest deficiencies or incomplete items, involving the CM/GC or others as necessary. Once all deficiencies are corrected, the BECxP recommends approval of the mock-up configuration to the CM/GC.
3. Items left incomplete that later cause deficiencies or delays during functional testing may result in back charges to the responsible party.

3.8 REPAIR AND PROTECTION

- A. The CM/GC is responsible for all repair and protection, regardless of the assignment of responsibility for testing, inspection, sampling, or similar services. Following completion of inspections, testing, sampling, or other quality control activities, the CM/GC shall:
1. Repair any construction damage during such activities using materials and methods consistent with the Contract Documents.
 2. Restore substrates, finishes, and affected construction to their original condition.
 3. Provide protection for construction exposed by quality control activities.
 4. Protect all repaired construction from subsequent damage.

3.9 TRAINING

- A. BECxP shall coordinate, schedule, and document training for all commissioned building enclosure systems. Training shall be conducted in accordance with the requirements specified in Section 019113, General Commissioning Requirements.

3.10 FINAL BECx REPORT

- A. The BECxP shall provide a final Building Enclosure Commissioning (BECx) report that includes all information generated during the BECx process, including, but not limited to:

1. BECx meeting minutes
 2. Design review reports
 3. Test reports
 4. Final Owner's Project Requirements (OPR)
 5. Basis of Design (BOD)
 6. Final BECx Plan
 7. Issues log
 8. Site observation reports
 9. As-built drawings provided by the CM/GC
 10. Submittals
 11. Record of training
 12. Operation and maintenance manuals
- B. The BECxP shall ensure the final BECx report is included as part of the project's final commissioning report, in accordance with Section 019113, General Commissioning Requirements. The report shall be submitted within 14 calendar days of completion of all commissioning activities, including the 10-month warranty review.

END OF SECTION 019115