Building Envelope Commissioning & Retro-Commissioning

Envelope Tech Team Meeting

June 13, 2017
2 to 3pm ET
Connecting Better Buildings partners with advanced building envelope technology solutions

- Technology verification studies
- Specification documents
- Case studies and fact sheets
- Calculators and analytic tools

Melissa Lapsa, M.B.A.
Simon Pallin, Ph.D.
Mahabir Bhandari, Ph.D.
Caroline Hazard, M.S.
Engage and support Members in efforts to accelerate adoption of building envelope technologies

- **Build awareness** with guidance and information on envelope technology solutions
- Conduct envelope technology verification studies
- Offer **technical assistance** for envelope projects
## Members

(includes: Building Owners/Mgrs, Property Managers, A&E, Construction/ Installers)

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<th>Members</th>
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<td><strong>Adams 12</strong></td>
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<td><strong>Allegheny County Community College</strong></td>
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<td><strong>Arlington Initiative to Rethink Energy (AIRE)</strong></td>
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<td><strong>Association for Energy Affordability</strong></td>
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<td><strong>Brevard County School Board</strong></td>
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<td><strong>Clark Atlanta University</strong></td>
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<td><strong>Cook County Bureau of Asset Mgmt</strong></td>
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<td><strong>Department of Commerce</strong></td>
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<td><strong>Emory University</strong></td>
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<td><strong>exp US Services, Inc.</strong></td>
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<td><strong>Green Dinosaur Inc.</strong></td>
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<td><strong>Hersha Hospitality Mgmt</strong></td>
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<td><strong>Instituto Superior de Engenharia do Porto</strong></td>
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<td><strong>Legacy Health</strong></td>
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<td><strong>MA Dept of Energy Resources</strong></td>
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<td><strong>Parkway Schools</strong></td>
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<td><strong>Smart Building Strategies LLC</strong></td>
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<td><strong>TN Office of Energy Programs</strong></td>
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<td><strong>US Army Corps of Engineers</strong></td>
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Join the Team!

Friends
(Includes: Researchers, Academics, Trade Associations, Energy Service Providers, Manufacturers, Subject Matter Experts)

- AppleBlossom Energy, Inc.
- Argonne Nat’l Lab
- BA Consult
- Birch Point Consulting
- BROAD U.S.A. Inc.
- Building Envelope Materials (BEM)
- Covestro LLC
- Guardian Glass
- ICF
- KUPU
- National Fenestration Rating Council
- NRG Insulated Block
- QuadLock
- Renovate by Berkowitz
- Rmax Operating, LLC
- SOLARIA
- Sustainability Consultants LLC
- UNIFRAX
- USG Corporation
Agenda

- Introduction - Why Building Enclosure Commissioning?
  - Simon Pallin, PhD, ORNL

- Going Deeper: Building Enclosure Commissioning and Retro-Commissioning
  - Paul Totten, PE, LEED AP, WSP

- Questions and Group Discussion

- Identify and prioritize Team Member resource needs

- Wrap up and adjourn
Introduction - Why Commissioning

- Holistic Building Envelope Assessment
- Installation Quality – Built as Designed
- Return of Investment
- Optimized Energy Performance
- Building Certification – LEED
- Users Comfort
Holistic Building Envelope Assessment

- Water Resistive Barrier
- Air Barrier
- Thermal Resistance
- Vapor Barrier
- Light
- Noise
- (Structural Performance)
Introduction - Why Commissioning

Holistic Building Envelope Assessment
Introduction - Why Commissioning

Example – Reduce energy losses through existing building envelope

Concerns - Impact on façade material
Introduction - Why Commissioning

Holistic Building Envelope Assessment
Introduction - Why Commissioning

Holistic Building Envelope Assessment

Freezing >100 freeze/thaw cycles
Introduction - Why Commissioning

Installation Quality – Built as Designed
Introduction - Why Commissioning

Installation Quality – Built as Designed

Field Study - Airtightness of 12 Identical Buildings

Factors that influence airtightness

• Construction design
• Floor area / Volume
• Penetration / Installations
• Material properties
• Workmanship
Introduction - Why Commissioning

Installation Quality – Built as Designed
Introduction - Why Commissioning

Return of Investment

1. **Energy charges**
   - Total amount of energy used

2. **Demand charge**
   - Highest 15-minute peak each month
# Introduction - Why Commissioning

## Return of Investment

<table>
<thead>
<tr>
<th>Customer A</th>
<th>Customer B</th>
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<tr>
<td>50 kW load for 50 hours:</td>
<td>5 kW load for 500 hours:</td>
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<tr>
<td><strong>Usage</strong></td>
<td><strong>Usage</strong></td>
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<tr>
<td>Energy = 50 kW x 50 hours = 2,500 kWh</td>
<td>Energy = 5 kW x 500 hours = 2,500 kWh</td>
</tr>
<tr>
<td>Demand = 50 kW</td>
<td>Demand = 5 kW</td>
</tr>
<tr>
<td><strong>Bill</strong></td>
<td><strong>Bill</strong></td>
</tr>
<tr>
<td>Energy = 2,500 kWh x $0.15 = $375.00</td>
<td>Energy = 2,500 kWh x $0.15 = $375.00</td>
</tr>
<tr>
<td>Demand = 50 kW x $28.00 = $1,400.00</td>
<td>Demand = 5 kW x $28.00 = $140.00</td>
</tr>
<tr>
<td>Total = $1,775.00</td>
<td>Total = $515.00</td>
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Identical energy usage, but very different totals due to PATTERN of energy usage.
Today’s Speaker

Paul Totten, PE, LEED AP
Vice President
Building Enclosures

YEARS EXPERIENCE
20

AREAS OF PRACTICE
Enclosure Design and Consulting
Enclosure Commissioning
Building Science

Email:
paul.totten@wsp.com
Building Enclosure Commissioning under LEED v4 and Retrocommissioning

Paul Totten, PE, LEED AP
Presentation Outline

- Enclosure commissioning process
- Retro-commissioning
- Project Examples
- Questions
Building Examples and Types for BECx
Building Examples and Types for BECx
A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner’s Project Requirements.

(ASHRAE Guideline 0-2005)
Commissioning Guidelines
Building Enclosure Commissioning Standard

ASTM E2813 Standard

- Includes qualifications for those performing BECx
- Based on NIBS Guideline 3 as the process for commissioning

Standard Practice for Building Enclosure Commissioning

This standard is issued under the fixed designation E2813; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Building Enclosure Commissioning (BECA) is a process that begins with the establishment of the Owner’s Project Requirements (OPR) and endeavors to ensure that the exterior enclosure and those elements intended to provide environmental separation within a building or structure meet or exceed the expectations of the Owner as defined in the OPR. A fundamental understanding of the most current published edition of ASHRAE Guideline 0 and NIBS Guideline 3 is recommended for optimal use and application of this practice.
Where’s the Value in BECx?

— Higher level of quality assurance = improved performance = reduced risk.

— Potential for risk reduction increases with complexity of building enclosure systems and materials.
Building Enclosure Commissioning Process

- Pre-Design Phase
- Design Phase
- Construction Phase
- Occupancy and Operations Phase
Building Enclosure Commissioning Process

OPR/BOD

Design Reviews – DD and CD

Construction Phase

Close Out
Building Enclosure Commissioning Process
Fundamental Prerequisite – LEED v4

OPR/BOD

Design Review – CD
Enhanced Credit – LEED v4

- Design Review – DD
- Construction Phase
- Close Out
Roles and Responsibilities
Basis of Design: Commissioning under LEED

**OPR**
- Energy Consumption Goals
- Tolerance for Water Leaks

**BOD**
- Roof Insulation (R-25)
- Hot-applied waterproofing
- Soldered Flashing
Owner’s Project Requirements (OPR)

- Owner’s Vision
- Project Budget and Schedule
- Owner Directives
- Occupant Requirements
- System Performance Requirements
- Statistical and Quality Tools
- Benchmarking Requirements
- Operation and Maintenance
- Allowable Range of Operation
- Applicable Codes and Standards
Owner’s Project Requirements (OPR)

- System Integration Requirements
- Site Information
- Restrictions and Limitations
- Training Requirements
- Warranty Requirements
- Quality Requirements
Design Reviews

— Review of drawings and specifications
  • Compare to OPR and BOD
  • Typically completed at Schematic Design, Design Development, and Construction Document phases
  • Present a system options comparison
  • Review transitions between enclosure systems
  • Identify material compatibility issues
  • Review HVAC interaction with enclosure
Design Reviews

- Below-Grade
- Wall Assemblies/Cladding
- Fenestration/Curtain Wall
- Roofing
- Interfaces between Assemblies

Heat Transfer
Air Flows/Pressures
Vapor Drive/Bulk Water Transport
Design Concepts - Window Flashing

Draft: Not for Construction

Concept drawings for review and consideration by the Architect of Record for incorporation into their design drawings.

Option 1: Remove brick return, install flashings and reset brick, set window.

Option 2: Leave brick return in place and build small pocket at sill to accommodate flashing.

Option 3: Fill in brick return and build flashing to infill.
March 9, 2016

WSP Comments for Consideration by the Design Team.

Our comments on the drawing set identify concerns as they relate to the exterior assemblies.

We have identified many of our comments by color coding to make it clear as to what aspect of air or water tightness, thermal barrier continuity, or risk of diffusive vapor transport they pertain to. A fifth color indicates general concerns. Please see the legend below for further description.

Where details are similar in nature, comments on other similar details apply to these details and all details with similar configurations should be reviewed to evaluate changes the design team may wish to make based on our comments.

Consider exaggerating the line weights of components for better clarity of design intent. Also consider identifying each component, rather than combining key notes, in order to establish a better understanding of system continuity, lapping, and installation sequencing considerations. General notes could be added to better describe lapping considerations (shingle style on vertical, guidance on embedment of flashings into hot-applied system and similar critical sequencing of waterproofing and flashing work).

LEGEND FOR WSP COMMENTS:

**ORANGE** represents GENERAL comments.

**BLUE** represents comments related to the WATERPROOFING and FLASHING systems.

**RED** represents comments related to the THERMAL BARRIER systems.

**GREEN** represents comments related to the AIR BARRIER systems.

**YELLOW** represents comments related to the VAPOR BARRIER systems.

Consider illustrating the at-grade and below-grade waterproofing layers to provide more clarity for scoping and installation requirements.

Provide redundant waterproofing at dowel and other penetrations through the waterproofing system. This may require a small waterproofing boot turned onto the dowel.

Consider a slight slope on the concrete to promote positive drainage. Please verify as notes imply this will be done, but not shown graphically.
Design Reviews – Roof Membrane Penetrations

- Consider installing a stainless steel sheet metal cover with hemmed edge and secured with a clamp to protect the roofing membrane from UV exposure.

- Consider extending the hot-applied membrane and neoprene sheet a minimum 6-inches above the finish height of the pavers and ballast. Terminate leading edge of membrane with a ring clamp.

- Where possible, consider installing pre-fabricated pipe flashing.

- Install a thermal break (neoprene) pad at bolt-to-plate and plate-to-slab conditions to reduce the risk of thermal bridging.

- Verify condition on underside of roof slab. If uninsulated, consider installing insulation on the underside of the slab at roof anchor conditions to reduce the risk of thermal bridging.

- Membrane detail is illustrated differently on either side of the pipe.
Design Reviews – Parapet Flashing

Stopping the hot-applied roofing system at this height creates a risk for water infiltration through deficiencies in the concrete wall (including sealant joints, the coating, and slab).

Refer to our concept sketch recommendation on the right.

If terminating at this height is desired, a regret set membrane termination with sheet metal counter flashing would be recommended.

Stop off the hot-applied roofing system at this height creates a risk for water infiltration through deficiencies in the concrete wall (including sealant joints, the coating, and slab).

Refer to our concept sketch recommendation on the right.

If terminating at this height is desired, a regret set membrane termination with sheet metal counter flashing would be recommended.

Refer to similar WSP comments on Details 1A6500.1.

Compressible filter sealant and backer rod.

Air and weather barrier: Apply along full face of wall. Seal all penetrations including brick ties, pipes, and mechanical equipment.

High temperature ice and water shield membrane: Lap over top of blocking and down sides. Tie into membrane below.

High temperature ice and water shield membrane: Lap over top of concrete parapet onto hot-applied roofing system and air and weather barrier.

Provide a glass-mat faced sheathing (such as Dens-Glass) on top of the insulation.

Hot-Applied Roofing System include flexible flashing: Turn up onto vertical face of parapet and lap onto top of sheathing at masonry wall.

3-feet minimum under roof deck.

Thermal bridging occurs at the back of the concrete parapet wall and floor slab creating a higher potential for energy inefficiency, condensation, and cold spots along the ceilings/floors.

Consider installing rigid insulation along the vertical surface of the parapet or at the underside of the roof deck to reduce the risk of thermal bridging.

If installing at the back of the parapet, install rigid extruded polystyrene insulation anchored or adhered to the concrete.

Provide a glass-mat faced sheathing (such as Dens-Glass) on top of the insulation. Install the roofing system on top of the sheathing.

If installing on the underside of the roof deck, install insulation 3-feet minimum into the space.
Design Reviews – Two Stage Sealant Joints
Design Reviews – Terrace Conditions
HVAC Interaction with Enclosure
HVAC Interaction with Enclosure
Verify Submittals

- Shop Drawings
- Product Submittals
- Project Schedule
Mock-ups and Testing

- Observation of Laboratory and Field mock-up construction
  - Not just for aesthetics
  - The standard for acceptable construction
- Review mock-up for general conformance to the construction documents and approved submittals
- Review constructability issues
- Review sequencing issues
- Opportunity for enclosure system functional performance testing (lab and field)
Laboratory Functional Performance Testing
Field Functional Performance Testing
Field Functional Performance Testing
Construction Observation
Construction Observation
Building Enclosure Commissioning under LEED v4

Paul Totten, PE, LEED AP
Vice President
Practice Leader
Building Enclosures
Paul.Totten@wsp.com

http://www.wsp.com/
Discussion... Tell us what you think

LEED certification
  ▪ Options?

Metrics in Building Envelope Performance
  ▪ Too many?
  ▪ Complicated?
  ▪ Better metrics needed?

Are buildings built as designed?
  ▪ Lack of communication? Actions needed?
  ▪ Are envelope systems too complicated? Are more bulletproof systems needed?
  ▪ Conflicts between trades?

What are the costs?
Discussion... Tell us what you think

Retrofit Commissioning, RCx

- What is the difference? Cx vs. RCx?
- Building owners incentives?
- Barriers?
- Missing certification programs?
- Can new construction metrics apply to retrofits?
- Other…
Action Items
Get Involved with the Tech Team!

Email: lapsamv@ornl.gov

- **Join** the team
- Send us your **feedback** on our Envelope Tech Team webpages
- Provide input on **airtightness** requirements study
- Collaborate on **Technology Verification** opportunities

https://betterbuildingsinitiative.energy.gov/alliance/technology-solution/building-envelope