Automated Sealing of Home Enclosures with Aerosol Particles

Welcome to the Webinar! We will start at 11:00 AM Eastern Time

Be sure that you are also dialed into the telephone conference call:

Dial-in number: 888-989-7679; Pass code: 3599368

Download the presentation at: www.buildingamerica.gov/meetings.html

Date: October 14, 2011
Building America: Introduction
October 14, 2011

Chuck Booten
Chuck.booten@nrel.gov
• Reduce energy use in new and existing residential buildings
• Promote building science and systems engineering / integration approach
• “Do no harm”: Ensure safety, health and durability are maintained or improved
• Accelerate adoption of high performance technologies

www.buildingamerica.gov
15 Industry Research Teams

Alliance for Residential Building Innovation (ARBI)

NorthernSTAR Building America Partnership

Building America Retrofit Alliance (BARA)

Fraunhofer USA

ARIES Collaborative

Building Energy Efficient Homes for America (BeeHa)

PARR

Habitat Cost Effective Energy Retrofit Program

N.E.L.C.
The National Energy Leadership Corps
Mark P. Modera is a Professor in Civil and Environmental Engineering, as well as Mechanical and Aerospace Engineering, and holds the Sempra Energy Chair in Energy Efficiency, all at UC Davis. He is also the Director of the Western Cooling Efficiency Center (WCEC) at UC Davis, a partner in Building Industry Research Alliance (BIRA), a Building America research team.

Dr. Modera joined the WCEC from Carrier Corp., where he was a Vice-President, and from Lawrence Berkeley National Laboratory (LBNL). At LBNL, Dr. Modera was a Principal Investigator on many research projects, including an aerosol-based duct sealing process that he will discuss today.

Mark’s broad experience in research, business, entrepreneurship, education, and regulatory environments provides an excellent background for leading the WCEC in its mission of partnering to advance energy-efficient cooling systems.
Building America Webinar:
Sealing of Home Enclosures with Aerosol Particles

October 14, 2011
Building Industry Research Alliance

- Led by ConSol
- Concentrated Focus on Western United States
- 30+ industry partners:
  - Builders, Architects, Manufacturers, State Energy Offices and Utilities.
- BIRA works directly with partners to:
  - Provide cost-effective strategies to reach project goals and energy targets
  - Offer Technical Assistance during Building Construction
  - Evaluate and Integrate New/Emerging Technologies
  - Community-Scale Projects in New Construction and Retrofit Energy Efficiency
Western Cooling Efficiency Center

- Part of the Energy Efficiency Center at University of California, Davis
- Launched April 2007
- Current staff:
  - Over 20 people
  - Engineers and Physicists
  - Social Scientists
  - Graduate Students and Undergraduate Students
“MISSION: Partner with stakeholders to identify technologies, conduct research and demonstrations, disseminate information, and implement programs that reduce cooling-system electrical demand and energy consumption in the Western United States.”
Presentation Overview

- **Basic Concept**
  - Seal New-Construction Building Shells at Rough-In
  - Potentially Seal Existing Construction from attic and/or crawlspace
  - Reduce cost, get better tightness and automated certification

- **Current Effort**
  - Build upon existing duct sealing technology
    - Address lack of carrier flow and turbulent mixing
  - Obtain Proof of Concept
    - Use 8’ high box to mimic house
Building America Gaps Addressed by Research

- **Airtightness**: Airtightness Strategies - strategies related to "good, better, best" airtightness goals (Deemed Important by 43.4%)
- **Airtightness**: Air Leakage Paths - identify relative contributions of specific air leakage paths (Deemed Important by 36.6%)
- **Walls**: Insulating and Air Sealing Inaccessible Places - develop solutions to insulate and air seal inaccessible places within wall construction (example, double brick wall) (Deemed Important by 17.2%)
Test “House” Sealing Process

Test “House”
• 8’ by 4’ by 8’ Tall
• Six removable leakage plates
  • 1/10” slots in 1/8” aluminum
  • Top, high on wall, far on wall
• 14” round inlet near top of box
Test “House” Sealing Process
Test “House” Sealing Process
Test “House” Sealing Process

First Test: Using 100 ccm sealant, and no pressure control
Test “House” Sealing Process

First Test: Using 100 ccm sealant, and no pressure control
Lower Sealant Flow and Box Pressure

Box Leakage vs. Time

- 25 ccm 100 Pa target
- 100 ccm high press/flow
Performance Comparison

• Lowered sealant flow specifically to slow down process

• Test also included controlling the pressure in the box by modulating air flow (FOR SAFETY AND CONTROL PURPOSES)
  • Changed deposition process at leaks
    • Resulted in less sealant deposits around leaks
  • Decreased mixing velocities in box
    • Average jet velocity reduced from 7.2 ft/s to 4.0 ft/s
Sealant Deposition Pattern

100 ccm sealant, High flow/pressure

25 ccm sealant, 100 Pa target

Low wall leak opposite injection
Test Comparison:
Jet Velocity (Mixing) and Pressure (Deposition)

Jet Velocity [ft/s]

Sealing Elapsed Time [min]

Box Pressure [Pa]

Sealing Elapsed Time [min]

100 ccm High Flow
25 ccm 100 Pa Target
Systematic Sensitivity Experiments - Variables

- Pressure Across Leaks:
  - Higher pressure should increase particle removal in and around leaks

- Mixing within Box:
  - Mixing should help keep particles suspended, but could also increase deposition on walls

- Particle Size:
  - Smaller particles should be easier to keep suspended, but should not deposit as effectively in leaks

**NOTE:** With current experimental apparatus it is difficult to separately control pressure and mixing – pressure is increased by higher flow (i.e. mixing)
# Sensitivity Experiments

<table>
<thead>
<tr>
<th>Test</th>
<th>Sealant Solid Content</th>
<th>Liquid Sealant Flow Rate [ccm]</th>
<th>Solid Sealant Flow Rate [ccm]</th>
<th>Target Pressure [Pa]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>35%</td>
<td>25</td>
<td>8.75</td>
<td>none</td>
</tr>
<tr>
<td>B</td>
<td>35%</td>
<td>25</td>
<td>8.75</td>
<td>100</td>
</tr>
<tr>
<td>C</td>
<td>35%</td>
<td>25</td>
<td>8.75</td>
<td>50</td>
</tr>
<tr>
<td>D</td>
<td>18%</td>
<td>25</td>
<td>4.375</td>
<td>100</td>
</tr>
</tbody>
</table>
Sensitivity Experiments: Performance Metrics

- Time Required to Seal Leaks
- Sealant Required to Seal Leaks
  - only looking at sealant injected into box
- Sealant Deposition Pattern
  - where does sealant go?
Impact of Pressure Control on Sealing Profile

- Leakage [square inches]
- Elapsed Time [minutes]

Lines represent different pressure controls:
- Red: 100 Pa
- Green: No Control
- Blue: 50 Pa
Impact of Pressure Control on Sealing Profile

Time Required to Seal Leaks [min]

- no pressure control: 15 minutes
- 100 Pa: 12 minutes
- 50 Pa: 10 minutes
Impact of Pressure Control on Sealant Requirements

Sealant Required to Seal Leaks [gm]

- no pressure control: 120 gm
- 100 Pa: 100 gm
- 50 Pa: 80 gm
Sealant Distribution Pattern

How sealant deposition at different locations is determined

- **Leaks**: sealant removed from leaks and weighed after experiment
- **Layflat Inlet Tubing**: weighed before and after experiment
- **Floor of Box**: plastic sheet weighed before and after experiment
- **Ceiling of Box**: plastic sheet weighed before and after experiment
- **Walls of Box**: wall patches weighed before and after experiment
- **Lost Through Leaks**: calculated by subtraction
Impact of Pressure Control on Sealant Deposition

Sealant Deposition [gm]

- **Floor**
- **Leaks**

<table>
<thead>
<tr>
<th>Pressure Control</th>
<th>Sealant Deposition [gm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>30</td>
</tr>
<tr>
<td>100 Pa</td>
<td>20</td>
</tr>
<tr>
<td>50 Pa</td>
<td>15</td>
</tr>
</tbody>
</table>
Particle Size Manipulation

Sealant Dilution Used to Change Particle Size

- Nozzle creates fixed-size droplets
- Dilution reduces solid content of each droplet
- Once water is evaporated, smaller particles remain
- 1:1 dilution reduces particle diameter by factor of $2^{1/3}$
- Particle diameter reduced by ~20% on average

Liquid injection rate was not modified

- Solid sealant flow rate reduced by 50%
Impact of Particle Size on Sealant Use and Loss

- Total Sealant [gm]
- Escaped Sealant [gm]

Legend:
- 100 Pa
- 100 Pa Diluted
Impact of Particle Size on Sealant Deposition

- Sealing Time [min]
- Floor Sealant [gm]
- Leak Sealant [gm]

- 100 Pa
- 100 Pa Diluted
Summary and Conclusions

• Initial tests of aerosol sealing of enclosures are encouraging
  • Sealing rates in small (nominally quiescent) enclosure are as good or **better than that experienced in ducts**
  • Deposition on floor is comparable to deposition in leaks
  • Minimal deposition on ceiling and walls

• **Lower Operating Pressure**
  • Reduces overall sealing time and sealant use
  • Reduces sealant deposition in/around leaks
  • Small impact on floor deposition
Summary and Conclusions

- Smaller **Particle Size**
  - Did not impact the sealant required for sealing
  - Decreased deposition on floor
  - Decreased deposition around leaks
  - Increased sealant blown through leaks
Next Steps

Additional Box Tests
- Repeatability Tests
- Characterize velocity field in box – try mixing fans?
- Performance modeling

Actual Structure Tests
- Decouple mixing and leak pressures
- Decouple pressurization and particle generation
- Test horizontal spread issues
Thank you for attending the webinar

If you have any comments or ideas for future Webinars, please email webmasterbtp@nrel.gov

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