Using an Aerosol Sealant to Reduce Multifamily Envelope Leakage

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Project Team & Funding

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• The Energy Conservatory

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Multifamily Envelope Sealing: Opportunities and Challenges

• **Existing buildings.**
  • Thousands of units of leaky units do not meet current standards.
  • No/difficult/costly access to distributed air leaks. 10% to 25% reduction is challenging.

• **New Construction.**
  • New code (low rise: 3 ACH50) and EPA ENERGY STAR high rise (0.3 cfm50/sf) requirements
  • Single family approaches only recently starting to carry over to multifamily buildings. How can we do this more effectively for both exterior leakage and compartmentalization?
Aerosol Sealing Benefits:

• Reduced air infiltration energy costs & cold drafts
• Improved IAQ from reduced odor & contaminant transfer
• Reduced noise transmission
• Simultaneous air leakage testing documents results
• Potential savings for avoided conventional air sealing (?)
How does it do that?

No, really?

(animation video here)

The sealant is GREEN Guard Gold Certified for use in California school and health care facilities.
**Aerosol Sealing Process**

- Pressurize apartment
- Spray air sealing fog
- Sealant particles build up on gaps as they flow through the leaks

Similar to process used for aerosol duct sealing
Study Objectives

Demonstrate sealing capability and evaluate commercialization

- Refine sealing technique – measure leakage and noise transmission reduction & identify sealing locations
- How to incorporate into sealing strategy – preseal “large” leaks and protect horizontal surfaces as necessary
- Time estimates
- Model energy savings and ventilation/inter-apt flows

1. Sealed 18 units in 3 new construction buildings
2. Sealed 9 units in 3 existing buildings
Site Work Prep: pre-seal wide gaps

1 to 2 person-hours

Sprinkler head

Duct penetration

Range electric line

AC Line set

Low voltage wiring

Plumbing penetration
Site Work Prep: temporary sealing

For openings that need to remain open

- Exterior doors
- Exhaust fan ducts
- Plumbing penetrations
- Combustion vents
- Fill traps or cover waste line openings
- Shower handles
Site Work Prep: cover horizontal surfaces

Ideal: drywall mud/tape, no finished materials/surfaces, and bare floor

Not ideal: ready for occupancy

Temporary seals & covers: 3 to 7 person-hours
Site Work Prep: cover horizontal surfaces
**Site Work**

Set-up, Seal & Breakdown
- Blower door and nozzles
- Pressurization
- Spray sealant
- Open windows & purge
  
  **6 to 7 person-hours**

Remove Covers & Pack-up
- Care to not disturb seals
- Minimal clean-up

  **1.5 to 3.5 person-hours**
Sealing work: how long does it take?

14 to 22 person-hours: still learning

*Pre-seal: 1-2 hrs
*Clean-up: 1-2 hrs
*Aerosol seal: 6-7 hrs
*Unit prep: 3-7 hrs
*Post-test: 0.25 hr
*Additional clean-up
Sealed Penetrations
Sealed Penetrations
Sealed penetrations - black light photos
Leakage Reduced Over Injection Period

New construction
Floor area: 350 to 420sf
Sealed 4 in one day

Pre: 7.1 – 8.4 ACH50, Post: 0.9 – 1.4 ACH50
82% to 89% reduction
Leakage Reduced Over Injection Period

Existing units
Floor area: 230 to 250sf

Large leak behind kitchen cabinet

Pre: 12.0 – 17.2 ACH50, Post: 1.4 – 10.5 ACH50
39% to 88% reduction
Leakage Results: 18 New Construction Units

Average leakage: pre = 3.9 ACH50, post = 0.7 ACH50
54% to 95% below code requirement, average = 77%
Leakage Results: 9 Existing Units

Average leakage: pre = 14.6 ACH50, post = 4.8 ACH50
6 of 9 within 15% of new construction code requirement
Modeling Ventilation in Multifamily Buildings

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Curtis Harrington

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Model

- EnergyPlus

- **Ventilation model**: Airflow network
  - Calculates inter-zone flows
  - Accounts for wind and stack effects

- **HVAC Equipment**: 
  - Based on MN multifamily building stock
  - Heating provided by baseboard radiant heaters
  - Cooling provided by window air conditioners
Model - Construction

- 6-Story building model

- Floor plan:
  - 4 Units per floor
  - 1 Elevator shaft

- Construction:
  - DOE reference model construction
  - Window to wall ratio: 20%
Model – Ventilation Method

- Four ventilation strategies investigated
  - Exhaust only
  - Exhaust with some supply
  - Balanced
  - No ventilation

- Individual unit exhaust fans and balanced ventilators
Model – Leakage

Envelope leaks:

- Existing Building
  - Leaky: 9.5 ACH50 (existing data)
  - Sealed: 3 ACH50 (MN code?)

- New Building
  - Compliant: 3 ACH50 (MN code?)
  - Tight: 0.6 ACH50 (Passive House)

<table>
<thead>
<tr>
<th>ACH50</th>
<th>Exterior</th>
<th>Interior</th>
<th>Floor/Ceiling</th>
<th>Door</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.5</td>
<td>43%</td>
<td>34%</td>
<td>13%</td>
<td>9%</td>
</tr>
<tr>
<td>3</td>
<td>47%</td>
<td>18%</td>
<td>5%</td>
<td>29%</td>
</tr>
<tr>
<td>0.6</td>
<td>47%</td>
<td>18%</td>
<td>5%</td>
<td>29%</td>
</tr>
</tbody>
</table>

Table 1: Leakage distribution used in models
Results – Ventilation Flows

Annual building average fresh airflow per unit

- 9.5 ACH50
- 3 ACH50
- 0.6 ACH50

Vent Fan Flow

MN Code Req’t

0.6 ACH50 – 96 cfm50; depressurization???
Results – Interior Flows

Average Flow from Adjoining Apartment (CFM)

- Exhaust Only
- Exhaust & Some Supply
- Balanced
- No Vent

- 9.5 ACH50
- 3 ACH50
- 0.6 ACH50
Results - Annual HVAC Energy Use (New Buildings)

Average Annual Heating Energy Per Apartment (Therms)

- Exhaust Only: 12 (4% savings)
- Exhaust & Half Supply: 17 (8% savings)
- Balanced: 27 (11% savings)
- No Ventilation: 26 (18% savings)

Legend:
- 3 ACH50
- 0.6 ACH50
- Savings
Results - Annual HVAC Energy Use (Existing Buildings)

Average Annual Heating Energy
Per Apartment (Therms)

9.5 ACH50
3 ACH50
Savings

Exhaust Only
Exhaust & Half Supply
Balanced
No Ventilation

41 11%
56 17%
67 19%
68 25%
### Results – Summary Table

- **Impact of sealing air leaks in apartment buildings in Minneapolis**

<table>
<thead>
<tr>
<th>Energy End Use</th>
<th>New Buildings</th>
<th>Existing Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Savings</td>
<td>4–18%</td>
<td>11–25%</td>
</tr>
<tr>
<td>Cooling Savings</td>
<td>-4–1%</td>
<td>-7–1%</td>
</tr>
<tr>
<td>Transfer Air Reduction</td>
<td>81%</td>
<td>86%</td>
</tr>
</tbody>
</table>
Conclusions

- When aerosol sealing can be applied
  - New construction
  - Rehab
  - Change in occupancy (higher cost)
- New construction
  - 81% reduction & 77% below code
  - Heating savings ~ 27 therms/yr
  - 81% reduction in flow from adjacent units
- Existing units
  - 68% reduction & 6 of 9 within 15% new code
  - Heating savings ~ 67 therms/yr
  - 86% reduction in flow from adjacent units
- Balanced ventilation is crucial for new construction, exhaust or supply OK for existing
Future Work

Large Building Sealing with Department of Defense

- Sealing existing commercial buildings on military bases
- Lab testing of seal strength and durability
- Modeling energy savings due to large-building sealing

Building America

- Integrate sealing process into construction schedule
- Work with developers in CA and MN
- Test multiple options
Questions?