Diagnosing and Air Sealing Large Commercial and Residential Apartment Buildings

Hosted by:
Larry Harmon
Air Barrier Solutions, Inc.
“No Good Deed Goes Unpunished”
What is Air Barrier Solutions?

- Building envelope retrofit firm
- Existing building air barrier evaluations +/- 50 million SF annually
- Focus is on solving problems and getting buildings fixed
- We view our role as being a trusted advisor
- Generally several projects running in various states
- Private and public sector work
- We test what we fix wherever possible
- Quality assurance drives our firm
Why Air Barrier Solutions?

• Proprietary systems to lower costs and improve QA
• CHIEF\textsubscript{Plus} analytical tool for savings calculations
• Team of building evaluators with multiple decades of experience each
• Building reports are comprehensive and designed for implementation
• ASTM E783, ASTM E779, ASTM E1105 and ASTM E1186 testing methodologies are employed
• Building measures are supported by scopes for QA
• Boutique retrofits with state-of-the-art M&V
Airports to dog pounds
Secure federal facilities
Hospitals
Schools
Manufacturing
Commercial
Municipalities
Multifamily
Hospitality
Benefits of Building Envelope Retrofit

- Controls movement of air into and out of the building
- Reduces heat loss/gain
- Reduces dust, mold and pollutants in the building
- Reduces noise and odors
- Reduces condensation, mold and mildew
- Improves comfort and occupant experiences
- Helps control biologicals
You Should Not Be Trying To Airseal Big Buildings Without A…

Quality Assurance System
Key Concepts

- Muda – wastefulness
- Muri – unreasonable
- Mura – non-uniformity
- Poka-Yoke – mistake proofing
  - Don’t accept a defect
  - Don’t make a defect
  - Don’t pass on a defect
• Getting the task correct is the difference between a tight and leaky fix
• Continual QA keeps the team focused on the goal
• QA timing should be as close to the task as possible
• Air leakage testing as the final arbiter of a good seal-up really keeps the team focused
• Specifications
### Topic: Window Work
**Subtopic: Cast-in-Place Weatherstripping**

<table>
<thead>
<tr>
<th>Row</th>
<th>Title</th>
<th>Specification(s)</th>
<th>Objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Safety</td>
<td>Worker follows relevant safety practices</td>
<td>Safe work practices and uninjured workers</td>
</tr>
<tr>
<td>2</td>
<td>Site</td>
<td>Site will be protected by moving objects and shielding areas</td>
<td>Prevent damage to objects near the work</td>
</tr>
<tr>
<td>3</td>
<td>Prepare frame and window</td>
<td>Window frame ready for gasket material</td>
<td>Have the frame free of corrosion dirt and oils</td>
</tr>
<tr>
<td>4</td>
<td>Sealant</td>
<td>100% pure silicone</td>
<td>Well adhered, gap filling, durable gasket</td>
</tr>
</tbody>
</table>
• Specifications
• Training for consistency
**Description of Task:** Initial Inspection and Repair of Door

<table>
<thead>
<tr>
<th>Materials:</th>
<th>Tools &amp; Equipment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Self-tapping screws</td>
<td>• Screw drivers</td>
</tr>
<tr>
<td>• Machine screws</td>
<td>• Allen wrenches</td>
</tr>
<tr>
<td>• Tapcon with flush head that will countersink</td>
<td>• Hammer drill</td>
</tr>
<tr>
<td></td>
<td>• Driver</td>
</tr>
<tr>
<td></td>
<td>• Channel locks</td>
</tr>
<tr>
<td></td>
<td>• Hammer</td>
</tr>
</tbody>
</table>

*All materials must meet the job’s specifications*

<table>
<thead>
<tr>
<th>Desired Outcome(s):</th>
<th>Properly operating door prepped for weatherstrip removal or installation</th>
</tr>
</thead>
</table>

# Important Steps | Key Points | Reasons |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>What?</td>
<td>Logical steps that advance the work</td>
<td>Tips in the “Important Steps” that will:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Make or break job</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Prevent injury</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Make easier</td>
</tr>
<tr>
<td>How?</td>
<td></td>
<td>Why?</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Safety-related</th>
<th></th>
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<tbody>
<tr>
<td>Process</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>• Open and close door</td>
</tr>
<tr>
<td></td>
<td>• Inspect door’s operation for minor repair items that can be fixed within 5 minutes</td>
</tr>
<tr>
<td></td>
<td>• If repairs needed are beyond that timeline, make note of problems on Quality Checklist and turn into Supervisor</td>
</tr>
<tr>
<td></td>
<td>• Find out what needs to be adjusted before weatherstripping and fix if possible</td>
</tr>
<tr>
<td>3</td>
<td>• Inspect hinges and adjust if needed</td>
</tr>
<tr>
<td></td>
<td>• If door is striking the jamb, check for loose hinges and tighten</td>
</tr>
<tr>
<td></td>
<td>• If hinge-bound, loosen the hinge where it is inset to</td>
</tr>
<tr>
<td></td>
<td>• Loose hinges allow sagging of door and hitting jamb</td>
</tr>
<tr>
<td></td>
<td>• Hinge-bound doors tend to pop open and not close all the way</td>
</tr>
</tbody>
</table>
Training JIBs for door retrofits

• Door inspection and repair
• Door weatherstrip removal
• Door weatherstrip installation: +/- 17 versions
• Door closer adjustments
• Door final inspection and checklist
Select Proper Window Plug
Remove Sash Install Plug
Place On Non-Skid Work Surface
Use Pick to Remove Weatherstrip
Locate Manufacturer’s Crimps
De-burr with Multi Tool
Use GFCI For All Power Tools
Insert New Weatherstrip and Trim
Reassemble Sash if Necessary
Clean, Lubricate Latches, Reinstall
Quality Assurance System

- Specifications
- Training for consistency
- Real-time worker support
Step 1.

Assess opening size and select material consistent with the QAS Manual. Complete any roof-wall joint opening into the sides of the space.

Step 2.

Fit and install rigid sheet goods tying the wall or header system to the roof. Note some fire rated applications may use rockwool and Hilti mastic for this application.

Step 3.

Fasten all edges and air seal in place. In this instance adhesive 2-component foam has done both tasks – Smart!

Step 4.

Fire protect as necessary. Use of a Hilti fire rated mastic or in this case DC-315 paint over foam achieves the proper protection.
Quality Assurance System

- Specifications
- Training for consistency
- Real-time worker support
- Checklists tracking progress and results
New Bedford Department of Public Infrastructure
Overhead Door W/S Install Guide and Quality Checklist for
RU/OH Door ID: RU-1
Repair Required:

<table>
<thead>
<tr>
<th>Material List</th>
<th>Width</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door Size (WxH)</td>
<td>9.5 feet</td>
<td>9.5 feet</td>
</tr>
<tr>
<td>Channel Type</td>
<td>RU Clip-on</td>
<td>1.5in SSB</td>
</tr>
<tr>
<td>Sides</td>
<td>Top</td>
<td>Bottom</td>
</tr>
<tr>
<td>RU Clip-on</td>
<td>5.5in STR-LS</td>
<td>None</td>
</tr>
<tr>
<td>Brush/Seal Type</td>
<td>3in LSB</td>
<td>RU BTM Seal</td>
</tr>
</tbody>
</table>

Notes:

Quality Management Checklist

1. Write down known problems that may impact operation e.g. broken gear box

2. Cleaned metal/wood before installing
   - Yes [ ] No [ ] If no, fixed [ ] Yes [ ] No

3. Continuous bead of caulk behind all carriers
   - Yes [ ] No [ ] If no, fixed [ ] Yes [ ] No

4. Pieces are all correct length and match on each side, if piecing needed (can piece, must mirror cuts on each side)
   - Yes [ ] No [ ] If no, fixed [ ] Yes [ ] No

5. Continuous installation with no gaps all around door – 100% contact
   a. Top and sides have slight contact, but do not interfere with door operation
      - Yes [ ] No [ ] NA [ ] If no, fixed [ ] Yes [ ] No

Installed by:

Start Date/Time:
End Date/Time:

I (we) certify that all of the answers below are correct and this is a zero-defect installation:

Signature(s):

b. Bottom touches ground – no sunlight visible if floor is not uneven
   - Yes [ ] No [ ] NA [ ] If no, fixed [ ] Yes [ ] No

c. Tested fit/proper close after each piece installed
   - Yes [ ] No [ ] If no, fixed [ ] Yes [ ] No

d. If bottom is catching on side weatherstrip, trimmed metal back away from finseal
   - Yes [ ] No [ ] NA [ ] If no, fixed [ ] Yes [ ] No

6. Carriers are screwed within 1-2” of each end then evenly spaced approximately every 10”
   - Yes [ ] No [ ] If no, fixed [ ] Yes [ ] No

7. Tested door 10 times to make sure it is closing properly
   - Yes [ ] No [ ] If no, fixed [ ] Yes [ ] No

8. Work site is clean before proceeding
   - Yes [ ] No [ ] If no, fixed [ ] Yes [ ] No
Quality Assurance System

- Specifications
- Training for consistency
- Real-time worker support
- Checklists tracking progress and results
- Daily reporting
- JIB review essential for each building
- Mock up everything and test it
Value of a CFM Saved…

…it’s not just the money!
**CHIEF<sub>Plus™</sub> calculation tool:**

- Developed by Air Barrier Solutions, Inc.
- Thermal savings follow $U*A*\Delta T$
- Air leakage savings are based on formulae derived from ASHRAE Fundamentals
- Detailed data inputs
- Bin data for temperature and wind speeds
- Transparent
- “Hot” formulae
- Fit testing
- Detail tabs per building and summary tab per project
Fit Testing – Evaluate reasonableness of the model

• Vetting the savings estimates and building operational assumptions
• Looks at percentage of baseline savings – reasonable?
• Btu/SF/HDD for benchmarking
  • Does it make sense, given what we’ve found at the site?
  • Possible supplemental heat?
  • Possible errors in baseline data?
  • Building operations tweaks – seasonal usage/setback
• **Payback depends on:**
  - Fuel Rate
  - Electricity Rate
  - Efficiency of the HVAC equipment
  - Building operations/setbacks
  - Cost/complexity of measure
  - Labor Costs
  - Current baseline consumption
  - Average wind speed of the area
  - Height of building
CFM Savings Projections

- Height of building
- Shielding class
- BIN hours/average temperatures
  - Heating Occupied
  - Heating Unoccupied
  - Cooling Occupied
  - Cooling Unoccupied
- Average wind velocity
- Setpoints/occupied hours
Dollar Savings Projections

- Heating fuel costs
- Electricity/cooling energy costs
# CHIEF™ Plus Project Data

## Inputs - Oxford, CT

<table>
<thead>
<tr>
<th>Input</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDD (calcs use BINs)</td>
<td>6,375</td>
</tr>
<tr>
<td>CDD (calcs use BINs)</td>
<td>334</td>
</tr>
<tr>
<td>Avg. Wind</td>
<td>7.0</td>
</tr>
<tr>
<td># Stories</td>
<td>4</td>
</tr>
<tr>
<td>Shielding</td>
<td>3</td>
</tr>
<tr>
<td>Cost/MBMbtu</td>
<td>$10.00</td>
</tr>
<tr>
<td>Cost/kWh</td>
<td>$0.10</td>
</tr>
<tr>
<td>Occupied hours</td>
<td>84</td>
</tr>
<tr>
<td>Setbacks - heating</td>
<td>72/65</td>
</tr>
<tr>
<td>Setbacks - cooling</td>
<td>74/78</td>
</tr>
<tr>
<td>Heating System Efficiency</td>
<td>75%</td>
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## Outputs

<table>
<thead>
<tr>
<th></th>
<th>HO</th>
<th>HU</th>
<th>CO</th>
<th>CU</th>
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<tbody>
<tr>
<td>CFM Decreases - 1 door</td>
<td>13</td>
<td>12</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Savings/CFM Decrease</td>
<td>$1.10</td>
<td>$0.89</td>
<td>$0.07</td>
<td>$0.04</td>
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<tr>
<td>Total Savings</td>
<td>$25.68</td>
<td></td>
<td></td>
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### CHIEF Plus™ Higher Wind Speed

<table>
<thead>
<tr>
<th>Inputs - Oxford, CT (Impacts If Higher Avg Wind Speed)</th>
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</thead>
<tbody>
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<td>HDD (calcs use BINs)</td>
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<td>CDD (calcs use BINs)</td>
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<td>Avg. Wind</td>
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</tr>
<tr>
<td>Shielding</td>
</tr>
<tr>
<td>Cost/MMBtu</td>
</tr>
<tr>
<td>Cost/kWh</td>
</tr>
<tr>
<td>Occupied hours</td>
</tr>
<tr>
<td>Setbacks - heating</td>
</tr>
<tr>
<td>Setbacks - cooling</td>
</tr>
<tr>
<td>Heating System Efficiency</td>
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</table>

<table>
<thead>
<tr>
<th>Outputs</th>
<th>( H_0 )</th>
<th>( H_U )</th>
<th>( C_0 )</th>
<th>( C_U )</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFM Decreases - 1 door</td>
<td>14</td>
<td>13</td>
<td>9</td>
<td>9</td>
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<tr>
<td>Savings/CFM Decrease</td>
<td>$1.10</td>
<td>$0.89</td>
<td>$0.07</td>
<td>$0.04</td>
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<tr>
<td>Total Savings</td>
<td>$28.01</td>
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</table>
### CHIEF Plus™ Higher Utility Rates

#### Inputs - Oxford, CT (Impacts If Higher Utility Rates)

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDD (calcs use B/INs)</td>
<td>6,375</td>
</tr>
<tr>
<td>CDD (calcs use B/INs)</td>
<td>334</td>
</tr>
<tr>
<td>Avg. Wind</td>
<td>7.0</td>
</tr>
<tr>
<td># Stories</td>
<td>4</td>
</tr>
<tr>
<td>Shielding</td>
<td>3</td>
</tr>
<tr>
<td>Cost/MBtu</td>
<td>$13.50</td>
</tr>
<tr>
<td>Cost/kWh</td>
<td>$0.15</td>
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<tr>
<td>Occupied hours</td>
<td>84</td>
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<tr>
<td>Setbacks - heating</td>
<td>72/65</td>
</tr>
<tr>
<td>Setbacks - cooling</td>
<td>74/78</td>
</tr>
<tr>
<td>Heating System Efficiency</td>
<td>75%</td>
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</table>

#### Outputs

<table>
<thead>
<tr>
<th>Description</th>
<th>H₀</th>
<th>Hᵤ</th>
<th>C₀</th>
<th>Cᵤ</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFM Decreases - 1 door</td>
<td>13</td>
<td>12</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Savings/CFM Decrease</td>
<td>$1.49</td>
<td>$1.21</td>
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<td>$0.17</td>
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<td>Total Savings</td>
<td>$34.79</td>
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</table>
### Inputs - Miami, FL

<table>
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<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDD (calcs use BINs)</td>
<td>140</td>
</tr>
<tr>
<td>CDD (calcs use BINs)</td>
<td>2,886</td>
</tr>
<tr>
<td>Avg. Wind</td>
<td>8.9</td>
</tr>
<tr>
<td># Stories</td>
<td>7</td>
</tr>
<tr>
<td>Shielding</td>
<td>2</td>
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<tr>
<td>Cost/MMBtu</td>
<td>$25.90 (Electric)</td>
</tr>
<tr>
<td>Cost/kWh</td>
<td>$0.09</td>
</tr>
<tr>
<td>Occupied hours</td>
<td>168</td>
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<tr>
<td>Setbacks - heating</td>
<td>72/72</td>
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<tr>
<td>Setbacks - cooling</td>
<td>73/73</td>
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<tr>
<td>Heating System Efficiency</td>
<td>95%</td>
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### Outputs

<table>
<thead>
<tr>
<th></th>
<th>$O$</th>
<th>$U$</th>
<th>$O$</th>
<th>$U$</th>
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<tbody>
<tr>
<td>CFM Decreases - 1 door</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
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<tr>
<td>Savings/CFM Decrease</td>
<td>$7.04</td>
<td>$0.00</td>
<td>$25.60</td>
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<tr>
<td>Total Savings</td>
<td>$32.64</td>
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</table>
# CHIEF Plus™ Lower Wind Speed

<table>
<thead>
<tr>
<th>Inputs - Miami, FL (Impacts If Lower Avg Wind Speed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDD (calcs use BINs)</td>
</tr>
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</tr>
<tr>
<td># Stories</td>
</tr>
<tr>
<td>Shielding</td>
</tr>
<tr>
<td>Cost/MMBtu</td>
</tr>
<tr>
<td>Cost/kWh</td>
</tr>
<tr>
<td>Occupied hours</td>
</tr>
<tr>
<td>Setbacks - heating</td>
</tr>
<tr>
<td>Setbacks - cooling</td>
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<tr>
<td>Heating System Efficiency</td>
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</table>

## Outputs

<table>
<thead>
<tr>
<th>CFM Decreases - 1 door</th>
<th>H_O</th>
<th>H_U</th>
<th>C_O</th>
<th>C_U</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
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<tr>
<td>Savings/CFM Decrease</td>
<td>$5.33</td>
<td>$0.00</td>
<td>$19.62</td>
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<tr>
<td>Total Savings</td>
<td>$24.95</td>
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</table>
## CHIEF™ Plus™ Lower Utility Rates

### Inputs - Miami, FL (Impacts If Lower Utility Rates)

<p>| | |</p>
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<td>8.9</td>
</tr>
<tr>
<td># Stories</td>
<td>7</td>
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<tr>
<td>Shielding</td>
<td>2</td>
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<tr>
<td>Cost/MMBtu</td>
<td>$10.44</td>
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<td>Cost/kWh</td>
<td>$0.07</td>
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<tr>
<td>Occupied hours</td>
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<tr>
<td>Setbacks - heating</td>
<td>72/72</td>
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<tr>
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<tr>
<td>Heating System Efficiency</td>
<td>95%</td>
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### Outputs

<table>
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<tr>
<th></th>
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<th>C₀</th>
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<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Savings/CFM Decrease</td>
<td>$2.84</td>
<td>$0.00</td>
<td>$20.28</td>
<td>$0.00</td>
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<tr>
<td>Total Savings</td>
<td>$23.11</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• If the FL project were not all-electric, may still be very viable project
• Utility savings isn’t everything – in many cases it isn’t even “something”
  • E.g. solving humidity problems can stop mold/decaying building parts
  • Energy savings are a nice bonus, not the prime motivator
Payback? Not Always…

- Talk solutions, not savings
- Turns the dialog upside down
- Broaden “savings” to include more than utilities
  - Tomb plaster
  - Chapel deterioration
  - Lab rats not isolated
  - Apartments by fish market
  - Bedbugs/roaches at…
• Sometimes we’re successful, sometimes not
• Deeply engrained that payback = litmus test for “go/no go”
Retrofits for Stack Effect
Ice damming – yes even in commercial
Comfort issues – complaints and open windows
Building control issues – temp and pressure
Pollutants from parking or even vent stacks
Door closure – entry or elevator
Mold/mildew
Condensation
Common Stack Effect Measures

• Generally taller buildings
• Seal top of building
• Rooftop accesses
• Rooftop accesses
• Rooftop mechanical rooms
• Rooftop accesses
• Rooftop mechanical rooms
• Top of elevator shafts and rooftop stair towers
• Rooftop accesses
• Rooftop mechanical rooms
• Top of elevator shafts and rooftop stair towers
• Curtain wall to parapet
• Rooftop accesses
• Rooftop mechanical rooms
• Top of elevator shafts and rooftop stair towers
• Curtain wall to parapet
• Soffits
Seal the Top

• Rooftop accesses
• Rooftop mechanical rooms
• Top of elevator shafts and rooftop stair towers
• Curtain wall to parapet
• Soffits
• Rooftop exhaust fans
Ventilation Duct RO’s Can Be Big Leaks!
Stuck Dampers are Even Worse
• Rooftop accesses
• Rooftop mechanical rooms
• Top of elevator shafts and rooftop stair towers
• Curtain wall to parapet
• Soffits
• Rooftop exhaust fans
• Rooftop AHU’s
• Rooftop accesses
• Rooftop mechanical rooms
• Top of elevator shafts and rooftop stair towers
• Curtain wall to parapet
• Soffits
• Rooftop exhaust fans
• Rooftop AHU’s
• Flue/intake penetrations
• Rooftop accesses
• Rooftop mechanical rooms
• Top of elevator shafts and rooftop stair towers
• Curtain wall to parapet
• Soffits
• Rooftop exhaust fans
• Rooftop AHU’s
• Flue/intake penetrations
• Mechanical dampers
Common Stack Effect Measures

• Generally taller buildings
• Seal top of building
• Seal lower connections
• Entry doors
Lower Connections

• Entry doors
• Parking garages – entry and core slab
• Entry doors
• Parking garages – entry and core slab
• Loading docks – RU’s, entry doors, dock levelers and core slab
• Entry doors
• Parking garages – entry and core slab
• Loading docks – RU’s, entry doors, dock levelers and core slab
• Pedestrian bridges
Lower Connections

- Entry doors
- Parking garages – entry and core slab
- Loading docks – RU’s, entry doors, dock levelers and core slab
- Pedestrian bridges
- Soffits and overhangs
Common Stack Effect Measures

- Generally taller buildings
- Seal top of building
- Seal lower connections
- Seal floor to floor
• Core slab to curtain wall
Floor to Floor

• Core slab to curtain wall
• Electrical rooms
Floor to Floor

- Core slab to curtain wall
- Electrical rooms
- Telecom rooms
• Core slab to curtain wall
• Electrical rooms
• Telecom rooms
• Custodial closets
• Core slab to curtain wall
• Electrical rooms
• Telecom rooms
• Custodial closets
• Fire stairs
• Core slab to curtain wall
• Electrical rooms
• Telecom rooms
• Custodial closets
• Fire stairs
• Ventilation shafts
• Core slab to curtain wall
• Electrical rooms
• Telecom rooms
• Custodial closets
• Fire stairs
• Ventilation shafts
• Access panels to shafts
Wind Effect in Action
Common Wind Effect Issues

- Comfort issues: hot leeward, cold windward
- Lack of building control during windy weather
- Missing insulation – generally loose fill
- Drifting snow – in openings onto ???
- Water ingress – kinetic
- Panels dropping
- Door closure
• Soffit sealing
Cowabunga Jumbo Soffit
Chicago Bulls at Practice
Thermax Fitted/Spray Seal Started
Sealed and Painted With DC-315
Common Wind Effect Measures

• Soffit sealing
• Roof-wall joint sealing
Flutes are Critical
Common Wind Effect Measures

- Soffit sealing
- Roof-wall joint sealing
- Window weatherstrip
Common Wind Effect Measures

- Soffit sealing
- Roof-wall joint sealing
- Window weatherstrip
- Window trim sealing
Common Wind Effect Measures

- Soffit sealing
- Roof-wall joint sealing
- Window weatherstrip
- Window-trim sealing
- Floor-to-wall sealing
Common Wind Effect Measures

- Soffit sealing
- Roof-wall joint sealing
- Window weatherstrip
- Window trim sealing
- Floor-to-wall sealing
- Door weatherstripping
Mechanical Effect
• Building will not maintain pressure
• Humidity control not possible
• Comfort issues
• Building Automation System (BAS) loses building under certain conditions
• Severe stack effect issues in towers
• Building degradation issues
Seal Everything
Issues Lead to Opportunities

So many possibilities!
Low Rise Opportunities

- Roof Wall Joint and/or Roof
- Attached Soffits and Soffits
- Windows
- Roof of Fans
- Elevation Changes
- Doors
High Rise Issues
Technology Aids Innovation
Testing Anyone?

\[ Q = C \times \Delta P^N \]
Paths for Envelope Testing

- **ASTM E783** Field Measurement of Air Leakage Through Installed Exterior Windows and Doors
- **ASTM E779** Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
- **ASTM E1105** Field Determination of Water Penetration of Installed Exterior Windows, Skylights…
- **ASTM E1186** Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems
ASTM E779 – 10
Standard Test Method for Determining Air Leakage Rate by Fan Pressurization

• Quantitative test not a qualitative test
Issues Testing Existing Buildings

- How many fans becomes a real quandary
- Hole size limit of fan(s)
- Occupants
- Permissions
- Off-hours maintenance
- Expensive
- Time consuming
- All or part of the building
- Security concerns
• We ask permission to test every building we are retrofitting
• We do not charge – need data and QA
• Some will, some won’t: get over it
• Some buildings we cannot test – size, use, etc.
Process – Set Up Equipment

Have a plan prepared

Or regret being unprepared
Seal Intentional Openings/Disable Mechanicals
Locate Outdoor Pressure Taps
Finish Testing and Pack Up
Missing Sheathing into Soffit
Cover Up and Work Above
Really Cover UP
Poor Connection Between Components
Center Connector Not Connected
Subway’s Numbers: Phase 1

- **Pre-test:**
  - 134,500 CFM$_{75}$
  - 1.32 CFM$_{75}$ per SF of surface area
- **Post-test:**
  - 72,000 CFM$_{75}$
  - 0.71 CFM$_{75}$ per SF of surface area
- A little over 62,000 CFM$_{75}$ reduction
- ELA @ 10 PA dropped from 10,684 to 7,620
- ELA @ 4 PA dropped from 5,689 to 4,629
- Still a very leaky building
Ramifications of Phase 1

- Current HVAC system quit “overheating” and handled the load
- Building could be balanced and even pressurized
- If they do so, it will surly effloresce in a line around the ground and first-floor leakage
- If not finished, the building will need to be kept slightly negative
It is a Really Simple Building
• Energy was not the driver
• Facility management wanted to correct several problems
• Rain and snow intrusion
• Ice dams
• Comfort complaints
• Building was tight
• Low-cost job
Once Again, Lots of Cover Ups
Multiple Lines Sealing the Roof-Wall Joint
Window Trim Sealing
Phase 2 Will be the Exterior
New Seal Installed and Mock-up Completed
The Numbers

- **Pre-retrofit**
  - 13,949 CFM$_{75}$
  - ELA 1,239 sq in @ 4 Pa
  - 0.19 CFM$_{75}$ per SF of surface area

- **Pre-retrofit**
  - 11,842 CFM$_{75}$
  - ELA 617 sq in @ 4 Pa
  - 0.16 CFM$_{75}$ Pa per SF of surface area

- **Roughly 15% reduction**
- **Water intrusion in problem areas stopped**
# Maine School – No Air Barrier

## Test 1: Depressurization

**Airflow at 75 Pascals**

- 40337 cfm $\pm$ 7.1 %
- Range: 37466 to 43208

---

**CFM @ 75/sq ft**

**Leakage Areas**

- $EqL_A (10 \text{ Pa}) = 3601.4 \text{ in}^2 \pm 8.7 %$
- $EL_A (4 \text{ Pa}) = 2023.9 \text{ in}^2 \pm 15.3 %$

## Building Leakage Curve

**Coef. (C) = 3142.6 cfm/\text{Pa}^n \pm 25.5 %**

**Exponent (n) = .591 \pm .074**

**Correlation Coef. (r) = .99220**

**Corr Coef Squared (r^2) = .98447**

### Table

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<tr>
<th>Label</th>
<th>Base?</th>
<th>start</th>
<th>end</th>
<th>nobs</th>
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</table>
The Problem
The Problem
The Problem
Now an OSHA Confined Space
Solution: Encapsulate
Post-Retrofit Results

Test 2: Depressurization

Airflow at 75 Pascals
19936 cfm +/- 1.5%
Range: 19637 to 20234
--- CFM @75/sq ft

Leakage Areas
EqLA (10 Pa) = 1497.2 in² +/- 2.9%
ELA (4 Pa) = 777.8 in² +/- 4.6%

Building Leakage Curve
Coef. (C) = 1072.1 cfm/Pa^n +/- 7.4%
Exponent (n) = .677 +/- 0.020
Correlation Coef. (r) = .99967
Corr Coef Squared (r^2) = .99934
Palermo Results

• Roughly 15 person-hours for pre-test and
post-test
• 58% reduction in hole size @ 10 PA
• 62% reduction in hole size @ 4 PA
• CFM75 went from 40,337 to 19,936
• Reduction of 4.67 CFM75 per SF of ceiling
area treated – 0.32 CFM per $
• Reduction of 0.47 sq in per SF of ceiling
area treated – $31.36 per sq in
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New Bedford DPI Garage Pre-Test
New Bedford DPI Pre-Test Results

- Airflow at 75 Pascals
  - 13697 cfm

- Leakage Areas
  - EqLA (10 Pa) = 2840.0 in²
  - ELA (4 Pa) = 2341.3 in²

- Building Leakage Curve
  - Coef. (C) = 6491.0 cfm/Pa^n
  - Exponent (n) = .173
  - Correlation Coef. (r) = .00000
  - Corr Coef Squared (r^2) = .00000

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<tr>
<th>Label</th>
<th>Base?</th>
<th>start</th>
<th>end</th>
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<th>Total Flow</th>
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<td>95</td>
<td>-12.23</td>
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</table>
• Sewer repair
• Pothole fixers
• Water main breaks
• Striping and painting
• Snow plowing
• Keep the town going
• (14) 16’W x 10’H overhead doors in a masonry building
• Seemed like an interesting thing to test
New Bedford DPI Garage Post-Test
New Bedford DPI Post-Test Results

**Graph:**
- **Y-axis:** Building Leakage (cfm)
- **X-axis:** Envelope Pressure (Pa)
- Data points forming a nearly linear trend.

**Table:**
- **Columns:** Label, Base?, start, end, nobs, Avg Pressure, Total Flow
- **Rows:** Baseline, -65, -60, -55, -50, -45, post
- **Data:**
  - Baseline: True, 26, 141, 116, -0.14, 0
  - -65: False, 241, 270, 30, -63.47, 8589.3
  - -60: False, 300, 329, 30, -60.01, 8316.8
  - -55: False, 488, 4517, 30, 55.34, 7853.2
  - -50: False, 540, 569, 30, -49.92, 7450.7
  - -45: False, 590, 619, 30, -45.01, 6971.5
  - post: True, 741, 856, 116, -1.1, 0

**Text:**
- **Test 1:** Depressurization
- **Airflow at 75 Pascals:** 9538 cfm ±1.7%
- **Range:** 9371 to 9705
- **CFM @75/sq ft**

**Leakage Areas:**
- EqLA (10 Pa) = 841.6 in² ±8.3%
- ELA (4 Pa) = 470.4 in² ±12.8%

**Building Leakage Curve:**
- Coef. (C) = 724.5 cfm/Pa^n ±19.5%
- Exponent (n) = 0.597 ±0.049
- Correlation Coef. (r) = 0.99900
- Corr Coef Squared (r²) = 0.99800
- Roughly 8 person-hours pre-test and post-test
- 2 fans used due to power constraints
- Wind gusting to over 50 mph on pre-test
- 70% reduction in hole size @ 10 PA
- 80% reduction in hole size @ 4 PA
- $CFM_{75}$ went from 13,697 to 9,538
- Reduction of 4,159 $CFM_{75}$ from 728 lineal feet of weatherstripping = 5.72 $CFM_{75}$ per foot
- LA reduction: 2.75 sq in per foot at 10 PA
Pulaski Gym Pre-Test
Pulaski Gym Pre-Test Results

Airtightness Results (95% confidence, non-weighted fit)

- Reporting Pressure (Pa) 75
- Test to View test 1

Test 1: Depressurization

- Airflow at 75 Pascals
  13563 cfm +/− 0.8 %
  Range: 13454 to 13673
  0.585 CFM @75/sq ft (0.580 to 0.590)

- Leakage Areas
  EqLA (10 Pa) = 1299.1 in² +/− 2.9 %
  ELA (4 Pa) = 753.8 in² +/− 4.5 %

Building Leakage Curve
- Coef. (C) = 1228.4 cfm/Pa^n +/− 6.9 %
- Exponent (n) = .556 +/− 0.017
- Correlation Coef. (r) = .99963
- Corr Coef. Squared (r^2) = .99926

View / Edit Test Details
- Export to Tectite Express...
- OK

Copy Data Table to Clipboard
Pulaski Gym Post-Test
Pulaski Gym Post-Test Results

Airflow at 75 Pascals
10479 cfm +/- 2.1%
Range: 10256 to 10701
0.452 CFM @75/sq ft (0.442 to 0.461)

Leakage Areas
EqLA (10 Pa) = 969.8 in² +/- 8.1%
ELA (4 Pa) = 554.0 in² +/- 12.5%

Building Leakage Curve
\[ \text{Coeff. (C)} = 881.8 \text{ cfm/Pa}^{-n} \pm/ 19.1\% \]
\[ \text{Exponent (n)} = 0.573 \pm/ 0.048 \]
\[ \text{Correlation Coef. (r)} = 0.99896 \]
\[ \text{Corr Coef Squared (r²)} = 0.99792 \]
Pulaski Gym Results

- Roughly 8 person hours pre-test and post-test
- 25.5% reduction in hole size @ 10 PA
- CFM$_{75}$ went from 13,563 to 10,479
- Return grill blew open on post – out of time
- Porous brick masonry walls
- Roughly 50 lineal feet done as mock-up prior
- 330 sq in reduction @ 10PA: 0.95 sq in per lineal foot
- 8.86 CFM$_{75}$ reduction per lineal foot sealed
• Possible to test individual units or banks of units
• We use both duct blasters and an MLM calibrated-orifice device
• Depends on the amount of air and pressure required
• Failures are possible
Duct Blaster Pressurizing Door
MLM Device Testing Door Leakage
• We test to a prescribed building pressure meant to mimic seasonal conditions
• Pre and post testing is encouraged
• A real motivator for the installers: seeing immediate feedback
• 30 – 45 minutes to set up and run
• Useful data for future assumptions
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</table>
Site Leakage Detection

ASTM E1186 – 03

Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems
ASTM E1186 – 03

Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

• Section 4.2.1 Infrared Testing
ASTM E1186 – 03
Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

• Section 4.2.2 Smoke Tracer
ASTM E1186 – 03
Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

• Section 4.2.3 Air Flow Measurement Devices
DG-700 Pressure & Flow Gauge

DEVICE

TIME AVG

10.1

0.0

02/17/2016 10:46
ASTM E1186 – 03
Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

• Section 4.2.4 Sound Generation Devices
ASTM E1186 – 03
Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

- Section 4.2.5 Tracer Gas Testing
- Section 4.2.6 Chamber Testing with Smoke Tracers
- Section 4.2.7 Chamber Testing with Water
- Section 4.2.8 Specialized Testing – smoke bombs etc.
ASTM Section 4.2.8 Flotation Devices
Common retrofits
Unintentional Daylighting

The roof-wall connection
Roof-Wall Rules

• Generally $\frac{1}{2}$ the leakage is above what you are staring at
• Single-component foam will not work – adhesion and cure
• Often there are fire-rated issues
• Fall protection is vital
• Safety officer as well
• Use of PPE mandatory
Roof-Wall Leak Hotwire
Smoke Tracer Roof-Wall Joint
Industrial Roof-Wall and Beams!
Hotwire Reading Air Leakage at Column
Why Worry about the Flutes?
Decking-Joint Gap IR
Rooftop Fans
Rooftop Fan Issues

- They are often neglected: clean and lubricate
- Stuck or missing dampers are common
- Broken belts are more common
- Broken pulleys.....
- Missing or damaged dampers
- Bad or unsafe electrical
- Sometimes all of the above
• Go for thermal if there is building above it
• Normally, we continue a plane of airtightness aligned with the interior surface
• Rigid material – no bending, moving or sagging.
• Choose materials carefully – fire-rated example.
• We often use Thermax, 2-component foam and intumescent paint
Remember... no matter how bad your day is going... at least you're not stuck in a fence getting laughed at by a cow.
Spray Foam Very Carefully When Doing Soffits

- Never spray daylight
- Spray from the building toward the soffit
- Mocking up the other end would have helped
Sealing and Weatherstripping Windows, Doors and Skylights
Hotwire – Door Leaking
Window Seals
Got Weatherstrip?
Fenestration Wisdom

• Doors are hard – I know they look easy
• Many windows leak at the frame-to-wall juncture
• Most replacement windows leak due to the install
• Many windows can be retrofitted with weatherstrip
• Door stops can often have their gaskets changed
• Skylights are generally water tight but seldom air tight
Old – Works Better Than New

- Old boiler room door
- Automatic door bottom FR SR
- Door gaskets on carrier FR SR
- What happens in the boiler room stays there
Stage Doors

- Masonry repair
- Wood trim replacement
- Q-Lon door gaskets
- Fin-seal astragals and sweeps
- Safety officer for pedestrians and workers
- Lotta time and money
- Leakage reduction is huge
- Change “fuzz” wherever possible
- Sweeps top and bottom
- Astragals along sides of doors
- A careful install will really reduce the hole size
Deficient New Does not Mean Forever
You’re Free!

Thanks for your attention and patience.

Larry Harmon

www.AirBarrierSolutions.com