INFORMED MECHANICAL DESIGN THROUGH TESTED AIR LEAKAGE RATES
✓ Move towards more energy efficient structures
✓ Collaborative approach promoted by LEED, 2030 Challenge, others
✓ Increased level of air tightness required by energy codes, LEED, government organizations (USACE, GSA)
✓ Large building blower door testing becoming more common, established and required
✓ Connection between mechanical system size and increasing levels of tightness

✓ Mechanical sizing commonly done by rules of thumb and inaccurate assumptions for leakage

✓ Growing body of tested leakage results could be used to adjust and tune infiltration assumptions

✓ Opportunity for greater synthesis between disciplines of envelope on mechanical designers
Air infiltration value accounts for about 1/3 of heating system sizing.

Research has found infiltration does not have a great impact of cooling system sizing.

Infiltration assumptions come from rules of thumb, manuals, modeling guidelines, Codes, and professional experience.

These infiltration assumptions have rarely been verified through post construction field testing.

Since testing is now becoming more common, there is an opportunity to correlate mechanical system design with more realistic rates.
Implications of incorrect sizing

✓ Heating capacity oversized. Unnecessary up-front costs
✓ High-efficiency systems will short cycle, making them less efficient
✓ Air change rate less than needed for occupant fresh air and humidity control
Large building air leakage testing is in its infancy
Lack of a body of data for tested rates
Wide range of values and units in modeling programs such as ACH, CFM/SF of floor area, CFM/SF of wall area, hybrids.
Unit of measure among mechanical engineers and the building envelope consultants are not the same.
Conversion is a challenge.
- ACH vs. ACH50
- CFM/SF vs. CFM/SF @ 75 Pa
Risks in under sizing capacity
## Infiltration Assumptions

<table>
<thead>
<tr>
<th>Source</th>
<th>Infiltration Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typically used value</td>
<td>0.35 ACH</td>
</tr>
<tr>
<td>eQUEST (DOE)</td>
<td>0.038 CFM/SF of envelope area, or 0.5 ACH</td>
</tr>
<tr>
<td>EnergyPlus</td>
<td>1.8 CFM/SF @ 75 Pa</td>
</tr>
<tr>
<td>ASHRAE – Fundamentals Chapter 16.15 and 16.29</td>
<td>0.1-2.0 ACH (Residential)</td>
</tr>
<tr>
<td></td>
<td>0.5-2.0 ACH (Commercial)</td>
</tr>
<tr>
<td>RS-29 from Seattle Energy Code (modified Appendix G. ASHRAE 90.1-2007)</td>
<td>Designed leakage of 0.4 CFM/SF at 75 Pa to be modeled at 0.045 CFM/SF</td>
</tr>
</tbody>
</table>
✓ For infiltration, the air leakage rate as determined below shall be modeled at 100% when the building fan system is off, and at 25% when the building fan system is on, unless otherwise approved by the building official for unusually pressurized buildings. Per PNNL Report 18898, Infiltration Modeling Guidelines for Commercial Building Energy Analysis, the building air leakage rates as determined in accordance with Section 1314.6.2 at 0.30 in. w.g. (75 Pa) shall be converted for modeling in annual energy analysis programs by being multiplied by 0.112 unless other multipliers are approved by the building official (e.g. a tested air leakage of 0.40 cfm/ft² of building envelope area at 0.30 in. w.g. (75 Pa) would be modeled at 0.045 cfm/ft² of building envelope area). The Proposed Building air leakage rate shall be the same as the Standard Design. The Proposed Building shall comply with Section 1314.6.3.
### Air Leakage Rates

<table>
<thead>
<tr>
<th>Standard</th>
<th>CFM 75/ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK, Good Practice</td>
<td>0.71</td>
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<tr>
<td>ASHRAE – Leaky</td>
<td>0.6</td>
</tr>
<tr>
<td>General Services Administration (GSA)</td>
<td>0.4</td>
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<tr>
<td>Washington State</td>
<td>0.4</td>
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<tr>
<td>UK, Normal</td>
<td>0.36</td>
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<tr>
<td>ASHRAE – Average</td>
<td>0.3</td>
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<tr>
<td>LEED</td>
<td>0.3</td>
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<tr>
<td>International Green Construction Code</td>
<td>0.25</td>
</tr>
<tr>
<td>Army Corps of Engineers</td>
<td>0.25</td>
</tr>
<tr>
<td>2012 Seattle Energy Code - Predicted</td>
<td>0.25</td>
</tr>
<tr>
<td>UK, Best Practice</td>
<td>0.14</td>
</tr>
<tr>
<td>ASHRAE – Tight</td>
<td>0.1</td>
</tr>
</tbody>
</table>
CASE STUDIES
Bellingham, WA. October 2010

40 unit apartment building with ground floor commercial

Exterior nearly complete. Installation of finishes ongoing.

Tested in accordance with 2009 Washington State Energy Code.
Case Study One
Quantitative Testing
Qualitative Results
✓ Tested air leakage rate was 0.4 CFM/SF @ 75 Pa
✓ Mechanical assumed equivalent of 0.3 CFM/SF Natural.
✓ Using PNNL conversion factor, the tested rate equates to 0.045 CFM/SF Natural.
✓ This represents an over estimation of 670%
Case Study Two

- Seattle, WA, August 2011
- 86-unit apartment building
- Substantially complete
Case Study Two
Tested air leakage rate was 2.3 ACH50 (0.45 CFM/SF @ 75 Pa)

Mechanical assumed equivalent of .4-.5 ACH Natural. However, about \( \frac{3}{4} \) of this was due to induced leakage (ventilation).

The ACH50 equivalent of this infiltration value is about 2.

The design infiltration is equal to the tested leakage.
Going Forward

✓ More study needed to analyze the current methods infiltration assumptions are being calculated.

✓ A larger body of data from tested buildings with continuous air barriers is needed.

✓ Collaboration between enclosure and mechanical designers should increase.
BUILD YOUR STRUCTURE ON FACTS

QUESTIONS ?