JRS ENGINEERING
BUILDING ENVELOPE CONSULTANTS

INFORMED MECHANICAL DESIGN THROUGH TESTED AIR LEAKAGE RESULTS

Presentation Objectives

- Understand methods of describing tested air leakage results
  - Understand the role air leakage (infiltration) plays in mechanical system sizing
    - Overview of mechanical design assumption for infiltration
      - Understand Washington State and Seattle Energy Code requirements for air barriers

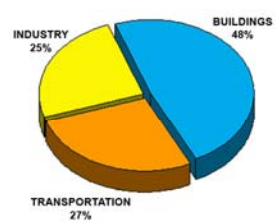
Outline

- ✓ Air Barrier requirements in Washington State Energy Code and other US jurisdictions
- ✓ Comparison of design assumptions for infiltration to tested air leakage rates
- ✓ Case Studies

CODE & JURISDICTION REQUIREMENTS

Energy Use in Perspective

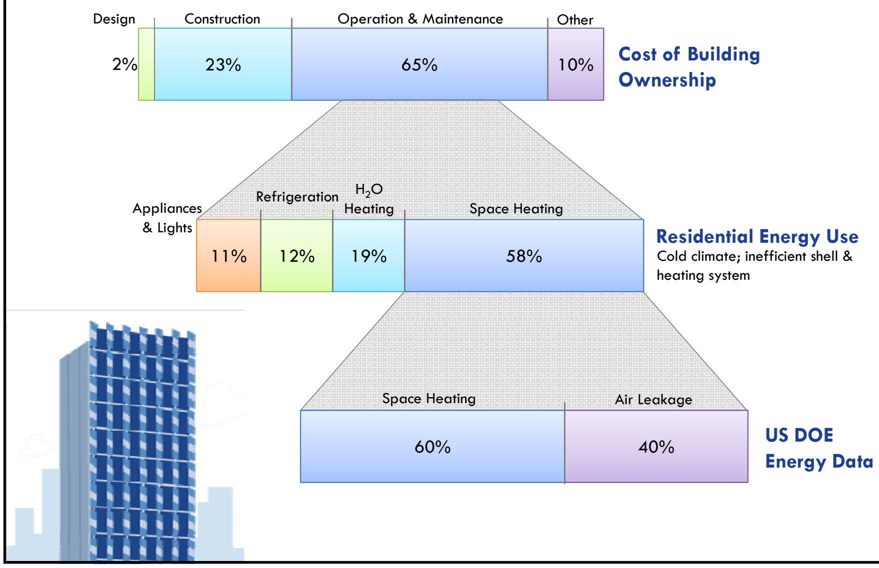
- ✓ 48% of US energy is used by buildings
- ✓ 76% of US electrical usage is for building operation & maintenance
- ✓ 40%-60% of energy use in commercial & residential buildings is for space heating and cooling



US ENERGY CONSUMPTION

- ✓ 40% of heat produced is lost to uncontrolled air leakage & infiltration
- ✓ 15% of heating load in office buildings due to infiltration
- ✓ When designing heating systems in the Pacific NW, mechanical engineers typically assume 1/3 of heat produced is lost to air leakage

Energy Use in Perspective



Jurisdiction Requirements

✓ Agencies that require continuous air barriers on commercial buildings:

- 2012 International Energy Conservation Code *(IECC)*
- Army Corp of Engineers *(USACE)*
- LEED for Homes - Midrise
- US General Services Administration *(GSA)*
- International Green Construction Code
- 2009 Washington State Energy Code
- 2009 Seattle Energy Code

2009 Energy Code Requirements

✓ Chapter 13 – Building Envelope (Section 1314.6) Requires **continuous** air barriers…

Washington State	Seattle Amendments
Buildings over 5 stories	All buildings (residential exception)
All components detailed	+ diagram of pressure boundary, calculate area for testing
Designed to meet 0.40 CFM/SF @ 75 Pa	(Same)
Certificate of Occupancy requires: Testing – do not need to pass. Report results	Certificate of Occupancy requires: **Opt 1** - inspect air barrier during construction. Test and report results. **Opt 2** - test and pass
ASTM E-779 Allows depressurization only	ASTM E-779+ Both pressurization and depressurization or pressurization only

Air Leakage Rates

0.4 CFM 75/SF equates to a 1.5 in^2 hole in 100 ft^2 of wall area

Standard	CFM 75/SF
UK, Good Practice	0.71
ASHRAE – Leaky	0.6
General Services Administration (GSA)	0.4
Washington State	0.4
UK, Normal	0.36
ASHRAE – Average	0.3
LEED	0.3
International Green Construction Code	0.25
Army Corps of Engineers	0.25
2012 Seattle Energy Code - Predicted	0.25
UK, Best Practice	0.14
ASHRAE – Tight	0.1

COMPARING DESIGN ASSUMPTIONS FOR INFILTRATION TO TESTED LEAKAGE RATES

Background

- ✓ 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

Background

- ✓ 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 and mechanical designers

Air Leakage and Mechanical Systems

- ✓ Air infiltration value accounts for about 1/3 of heating system sizing
- ✓ Research has found infiltration does not have a great impact on 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

Challenges in connecting the dots

- ✓ Large building air leakage testing in its infancy
- ✓ Lack of body of data for tested rates
- ✓ Wide range of values & units in modeling programs such as ACH, CFM/SF of floor area, CFM/SF of wall area, hybrids
- ✓ Unit of measure among mechanical engineers & building envelope consultants not the same
- ✓ Conversion is a challenge
  - ACH vs. ACH50
  - CFM/SF vs. CFM/SF @ 75 Pa
- ✓ Risks in under-sizing capacity

Infiltration Assumptions

Source	Infiltration Value
Typically used value	0.35 ACH
eQUEST (DOE)	0.038 CFM/SF of envelope area, or 0.5 ACH
EnergyPlus	1.8 CFM/SF @ 75 Pa
ASHRAE – Fundamentals Chapters 16.15 and 16.29	0.1-2.0 ACH (Residential) 0.5-2.0 ACH (Commercial)
RS-29 from Seattle Energy Code (modified Appendix G. ASHRAE 90.1-2007)	Designed leakage of 0.4 CFM/SF @ 75 Pa to be modeled at 0.045 CFM/SF

RS-29 Table 3.1 Item 5 (SEC addition)

- ✓ 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/ft^2 of building envelope area at 0.30 in. w.g. (75 Pa) would be modeled at 0.045 cfm/ft^2 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

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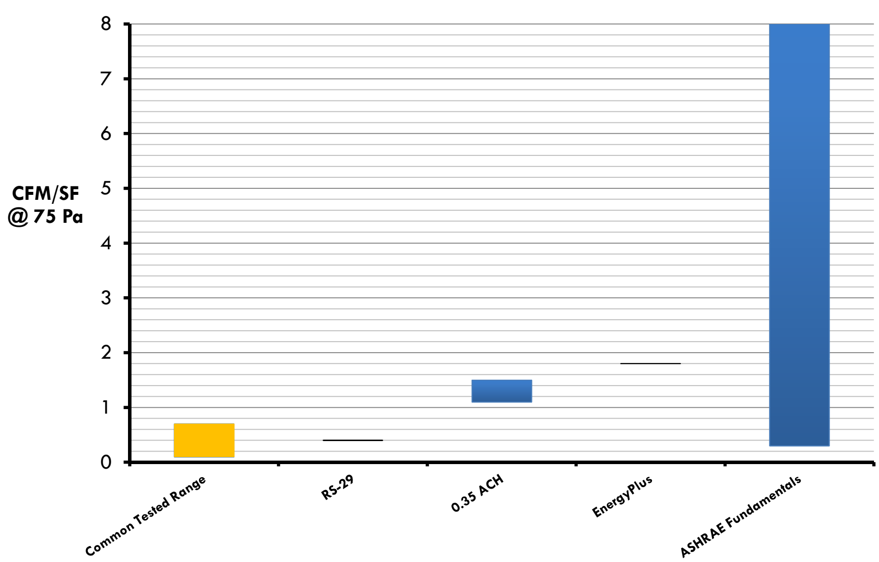
Comparison Chart



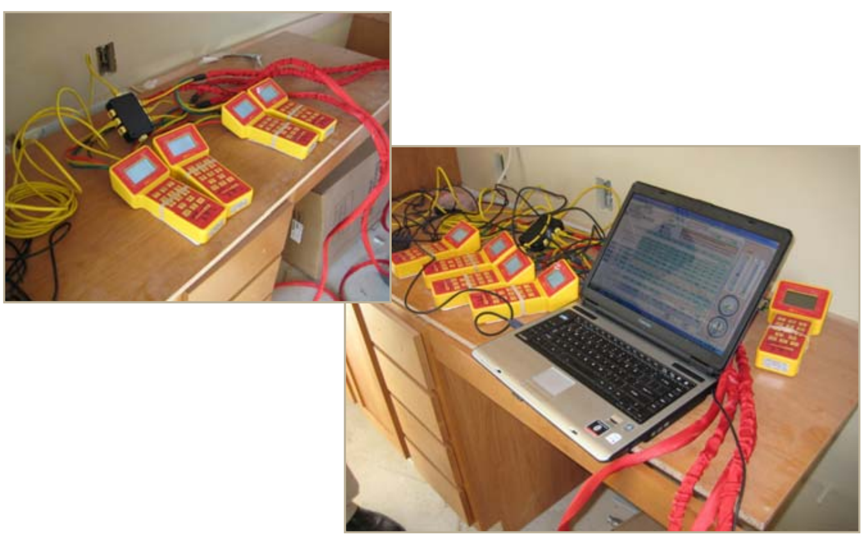
CASE STUDIES

Case Study One

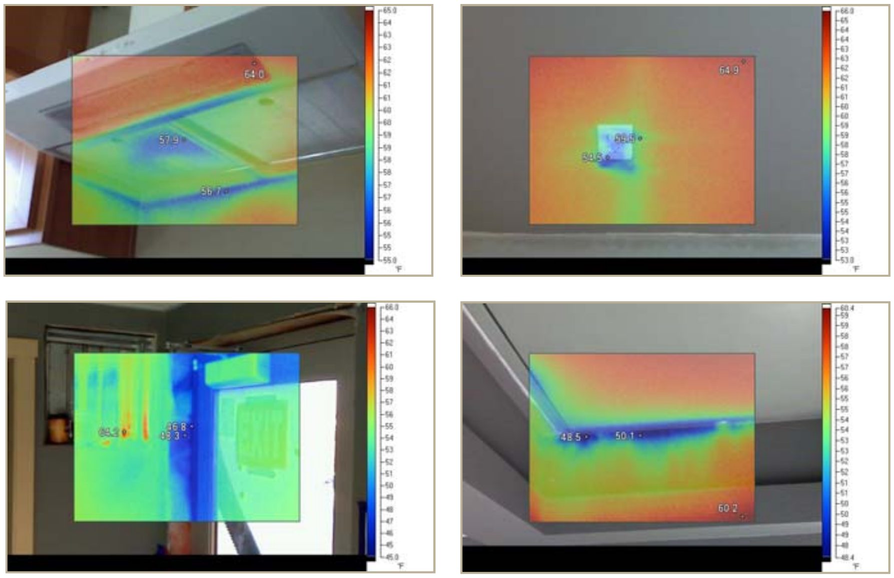
- ✓ Bellingham, WA; October 2010
- ✓ 40-unit apartment building with ground-floor commercial
- ✓ Exterior nearly complete; installation of finishes ongoing
- ✓ Tested in accordance with 2009 Washington State Energy Code

Case Study One

Quantitative Testing



Qualitative Results



How it Performed

- ✓ Tested air leakage rate = 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
- ✓ Tested in accordance with 2009 Washington State Energy Code

Case Study Two

Case Study Two

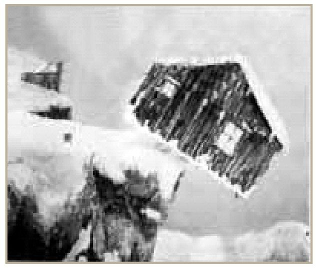
- ✓ Tested air leakage rate = 2.3 ACH50 *(0.45 CFM/SF @ 75 Pa)*
- ✓ Mechanical assumed equivalent of 0.4 - 0.5 ACH Natural. However, about ¾ of this was due to induced leakage (ventilation)
- ✓ The ACH50 equivalent of this infiltration value is about 2

- ✓ 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 ?

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