State of the Art of Multi-Unit Residential Building Airtightness: Test Procedures, Performance, and Industry Involvement

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Making Buildings Better
Outline

- Airtightness Test Procedures & Equipment
- Worldwide Regulatory Requirements & Targets for Airtightness
- Airtightness of Multi-Unit Residential Buildings
- Air Barrier Systems
- Industry Preparedness for Airtightness Testing
Why We Care – Why We Test
Measuring Large Building Airtightness

- Quantitative Testing – “Measure a Number”
  - Fan Door/Blower Door or use Building’s own HVAC system
  - Tracer Gas Testing
  - Several CAN/CGSB, ASTM, ISO & Other Industry Standards
    - Similar intent with slightly different procedures
    - Different test setups, acceptable conditions, readings
    - Dozens of different reporting units
  - Pressure neutralization techniques for measuring parts of larger buildings
- Typical Testing Costs: $2000 - $25000+
- Net Result (normalized airflow – cfm/ft², leakage area in² of hole)
Large Building Targets - Worldwide

- Washington State & Seattle, ABAA Target
  <0.40 cfm/ft$^2$ @ 75 Pa (<2.0 L/s·m$^2$ @75Pa)
- US Army Corps of Engineers, <0.25 cfm/ft$^2$ at 75 Pa (proposed down to 0.15 cfm/ft$^2$)
- Passivhaus, 0.6 ACH$_{50}$ (~0.12 cfm/ft$^2$ at 75 Pa)
- LEED, 6-sided apartment test
  (~0.23 cfm/ft$^2$ at 50 Pa)
- UK (AATMA) Large Buildings,
  ~0.14 to 0.35 cfm/ft$^2$ at 75 Pa
- Interestingly India, Qatar, Turkey, Dubai, Abu Dhabi and others also have testing reqs. <0.40 cfm/ft$^2$ at 75 Pa
- Canada – currently no requirement
Finding Large Building Air Leakage

- Qualitative Testing – “Seeing It/Finding It”
- Infrared Thermography (positive/negative pressures)
- Smoke Tracers/Generators
- Sound Transmission
- Leak Detection Liquid
- Manometers, Pressure Profiling

- Typical Costs: $500 to $2000+

- Net Result – Finds the leaks
MURB Airtightness Database >55 unique MURBs, >170 tests

Building Height, Stories

- 23, 35%
- 16, 24%
- 13, 20%
- 10 - 14
- 5 - 9
- 0 - 4
- Unknown
Airtightness of MURBs – cfm/ft² @ 75 Pa

Airtightness of MURBs versus Original Year of Construction

1 cfm/ft² = 5 L/s · m²
Flow Exponent (n) value for MURB Tests

Flow Exponent (n) value for MURBs

Average = 0.63

Note that these points are below the theoretical minimum of 0.5.

More on this topic in next presentation by Robin Urquhart
The Potential – US Army Corps Buildings

Airtightness of USACE Barracks Buildings

Airtightness [cfm/ft²]

1 cfm/ft² = 5 L/s·m²

Average = 0.19 (excluding outlier)

US ACE Target

0.25 ft³/min·ft²

at 75 Pa

This value is an outlier compared to the other US ACE values; however, is not unreasonable when compared with other non-US ACE testing.
Trends from Seattle – Past 3 Years of Testing

Modern Wall Air Barrier Strategies – RDH Seattle
Test Data, >30 buildings, mid- to high-rise

Average = 0.25 cfm/ft²

Code minimum
not that tight

very tight

tight

Liquid Applied
Curtain Wall/Window Wall
Sealed Sheathing
Sheet Applied
Trends from Seattle – Towards More Robust Air Barrier Systems

Loose Sheet Applied Membrane – Taped Joints & Strapping

Sealed Gypsum Sheathing – Sealant Filler at Joints

Liquid Applied Sealants/Membranes over Plywood or Gypsum Sheathing

Self-Adhered vapor permeable membrane

Self-Adhered vapor impermeable membrane

Curtainwall, window-wall & glazing systems
The Potential – Building Enclosure Retrofits

% Improvement in MURB Air Tightness Pre- and Post-Retrofit at 75 Pa

Average = 31%

Airtightness [cfm/ft²]
Industry Awareness & Preparedness Survey

- Survey sent to hundreds of architects, engineers, contractors and others responsible for design, implementation, and testing of air barrier systems in large buildings (in 2012)
  - 67 respondents across North America
- Potential for bias in survey
  - Respondents more likely to care about good air barrier performance and need for testing
  - Non respondents less likely to care or don’t perceive value
Industry Survey Respondents

Geographic Distribution of Responses:
- Canada: 48%
- USA: 48%
- Other Countries: 4%

Distribution of Qualifications:
- Engineer: 43%
- Energy Advisor or Auditor: 22%
- Technologist: 14%
- Architect: 15%
- Other: 6%
Why Address Airtightness in Buildings?

- **Energy**: [Bar Graph]
  - Red: 1 (Most Important)
  - Purple: 2
  - Blue: 3
  - Green: 4
  - Light Green: 5 (Least Important)

- **Moisture Control**: [Bar Graph]
  - Red: 1 (Most Important)
  - Purple: 2
  - Blue: 3
  - Green: 4
  - Light Green: 5 (Least Important)

- **Indoor Air Quality**: [Bar Graph]
  - Red: 1 (Most Important)
  - Purple: 2
  - Blue: 3
  - Green: 4
  - Light Green: 5 (Least Important)

- **Acoustics**: [Bar Graph]
  - Red: 1 (Most Important)
  - Purple: 2
  - Blue: 3
  - Green: 4
  - Light Green: 5 (Least Important)

- **Other**: [Bar Graph]
  - Red: 1 (Most Important)
  - Purple: 2
  - Blue: 3
  - Green: 4
  - Light Green: 5 (Least Important)
Effectiveness of Qualitative vs Quantitative Tests

Effectiveness of **Quantitative** & Need for Enforcement?

- Yes - Enforceable: 63%
- Yes - Not Enforceable: 25%
- No: 12%

What Target if Codified?

- 0.25 to 0.40 cfm/ft² @ 75 Pa

Effectiveness of **Qualitative** Testing

- Yes: 65%
- No: 35%
Could Air Tightness Capacity Be Met in Your Area?

- No Local Interest: 2%
- No Local Capacity: 25%
- Unsure: 13%
- Capacity Could Be Easily Met: 38%
- Capacity Currently Exists: 23%

Time to Develop Industry Capacity?

- <1 year: 23%
- 1-2 years: 37%
- 2+ years: 40%
Evolution & Market Transformation

Market Transformation Phases Towards Higher Baseline Airtightness in MURBs

Degree of MURB Airtightness in Canada

Past Performance

Initial Awareness

Past Research

Current Market Position

Increasing Integration

Voluntary Measures, Green Programs & Incentives

Airtightness Testing & Air Sealing Training

Market Drivers

Regulated Performance Standards

Standard Practice

Desired Future Market Position
Next Steps

Market Transformation Roadmap Towards Higher Baseline Airtightness in MURBs

- Market Drivers
  - Serendipitous Impacts (e.g., Leaky Building Repairs)
  - Research and Transformation Plan Development
  - Testing Methods: Development & Availability
  - Building Designer Expectations
  - Training of Builders and Testers
  - Testing Requirements in Adjacent Jurisdictions
  - Green Building Program Requirements
  - Incentive Programs
  - Warranty Program Requirements
  - Owner Expectations & Status Quo
  - Testing Standards & Requirements

- Degree of MURB Airtightness
  - Current Market Position
  - Market Research
  - Awareness & Education
  - Airtightness Testing & Air Sealing Training
  - Voluntary Measures, Green Programs & Incentives
  - Regulated Performance Standards

- Time (years)

- From Low to High Airtightness
→ Many different standards & methods to measure airtightness and locate air leakage in large buildings

→ Average airtightness of MURBs in database
  0.75 cfm/ft² @ 75Pa

→ Airtightness of newer MURBs and USACE barracks buildings much lower, 0.3 to 0.4 cfm/ft² @ 75Pa easily achievable

→ Many strategies for air barrier systems

→ Industry capacity and drivers in place
Questions

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