AIVC Conference on air-tightness

Air Tightness Performance of Whole Buildings: Design, Construction and Verification Testing
April 18-19, 2013

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Wiss, Janney, Elstner Associates, Inc.

Whole Buildings Airtightness Verification Testing

- ASHRAE 1478 RP
- Protocol and Testing
- Results of Research
- Other Results
ASHRAE 1478 RP
ASHRAE 1478 RP: Measuring Air-Tightness of Mid and High-Rise Non-Residential Buildings

Background
• Lack of scientifically gathered and reported data on modern mid- and high-rise non-residential buildings

Objective and Scope
• Measure and report air leakage rates for existing mid- and high-rise buildings
• Develop protocol for testing large buildings
• Analyze results with respect to design and construction parameters
• Complete study in 3 yrs

Key Players ASHRAE 1478 RP
• Wiss, Janney, Elstner, Associates, Inc. Principal Researcher
• Terry Brennan, Camroden Associates
• Gary Nelson and Collin Olson, The Energy Conservatory
• Dave Bohac, Center for Energy and Environment
• Larry Harmon, Air Barrier Solutions
• Jim Cummings and Chuck Withers, FSEC
ASHRAE 1478 RP Participants and Budget

- ASHRAE Research - $150,000
- Wiss Janney Elstner Research - $70,000
- Oak Ridge National Labs / DOE - $50,000
- DuPont Innovations - $30,000
- Energy Conservatory - equipment + expertise, $?
- Air Barrier Solutions - investigations, $?
- Camroden Associates - expertise, $?
- Center for Energy and Environment - $?

ASHRAE 1478 RP: The Plan

- Develop testing protocol
- Select buildings
- Prepare for testing
- Execute testing
- Report findings
- Write paper
- Propose changes to ASHRAE HOF
Current Protocols

- ASTM E779 - US Protocol
- ABAA/US Army Corps of Engineers Protocol
- CAN/CGSB -149.10
- ISO 9972 - International
- BS EN 13829:2001 – British standard
- CIBSE TM-23 Standard

Revised Protocol: Goals

- Address the challenges with testing larger buildings
- Allow reliable comparison of building sample
- Reliably Reproduce Results
- Consider aspects of design or construction
Challenges: Large modern buildings

• Pressure boundary definition
• More penetrations
• Stack and wind effects
• Measuring pressure differences
• Complex geometries
• Uniform air pressure distribution

Test Protocol: Measurements

• Depressurizing and pressurizing airflows
• Pressure differences induced across building enclosure
• Interzonal pressure differences
• Indoor and Outdoor air temperatures
• Wind speed, Gusting, Stack Effect
• Damper Leakage
Protocol Revisions/Considerations

- Blower doors vs mechanical equipment
- Creating a single zone vs sub-set of floors
- Weather Conditions and Stack Effect
- Measuring Building and Roof Pressures
- Contribution of HVAC penetrations
- Mechanical Room Doors
- Interzonal Pressure Differences
- Smoke testing

Test Protocol Equipment
Candidate Building Selection

• 16 Buildings Reported
• Non-residential
• 4 stories or higher
• Sustainability certification (14 of 16)
• Built after the year 2000
• Climate zones 2-7 (All 6 Zones Represented)

Challenges: Candidate building sample

• Owner interest
• Owner costs and responsibilities
• Location and climate zone
• Occupancy / Access
• Willingness to share data
• Timing
What more do we need?

- Pre-Test Preparation
- Logistics
- Test Day Preparation
- Test Execution

Pre-Test Preparation

Collecting information

- Construction documents and building data
  - Building plans and specifications
  - Mechanical schedule
  - Shop Drawings
- Preliminary site visit(s)
Pre-Test Preparation

Site Coordination

- Establish dates for testing
- Building personnel (HVAC, Electrical, Security)
- Identify security issues or special conditions
- Identify anticipated occupancy during testing

Pre-Test Preparation

Equipment

- Number of fans
- Distribution and cable/tubing runs
- Establish device mapping for data collection software
Test Day Preparation

Prepare HVAC System
• Open return air dampers (Create single zone)
• Close operable dampers (OA, exhaust, pressure relief)
• Close or mask gravity dampers
• Mask un-dampered exhausts
• Check for combustion equipment
Test Execution

Data Analysis and Calculations

![Graph showing Building Leakage vs Envelope Pressure]
Optional Investigations

- Penetration Masking
- Leakage Site Detection
  - Smoke
  - Infrared
Reporting and Documentation

• Reporting per ASTM E 779 Section 10
• Building and Systems Description
• Leakage Rates: Total Enclosure / Above Grade Enclosure
• Additional Metrics (ACH50)
Building 1: Office Building

Orlando, FL; Climate Zone 2B

<table>
<thead>
<tr>
<th>CFM75_{total}</th>
<th>CFM75/total A_{s}</th>
<th>CFM75/above grade A_{s}</th>
<th>ELA (in²)</th>
<th>E_qL A (in²)</th>
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<tr>
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</table>

Results

Building 2: Business Instructional Facility

Champaign, IL; Climate Zone 5
LEED Platinum

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<th>CFM75/total A_{s}</th>
<th>CFM75/above grade A_{s}</th>
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Results
Building 3: Corporate HQ

Maple Grove, MN; Climate Zone 6
LEED Platinum

Results

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<tr>
<th>CFM75_{real}</th>
<th>CFM75/total A_s</th>
<th>CFM75/above grade A_s</th>
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Building 7: Corporate HQ

Cambridge, MA; Climate Zone 5A
LEED Platinum

Results

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<th>CFM75_{real}</th>
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Building 7: Corporate HQ

Results from additional investigation include:
- A 16 Pa pressure difference between the double façade and the building
- Exterior façade was tighter than inner façade

Building 6: Office Building

Duluth, GA; Climate Zone 3A
LEED Gold

Results

<table>
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<tr>
<th>CFM75_{total}</th>
<th>CFM75/total A_s</th>
<th>CFM75/above grade A_s</th>
<th>ELA (in²)</th>
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Results: CFM75/Total As

![Graph showing CFM75/Total As results](image1)

Results: Increase in Volume Flow at CFM75 due to Unmasking

![Graph showing increase in volume flow](image2)
Common Problems

- Areas that should/may be outside pressure boundary
  - Loading docks
  - Mechanical, electrical, generator rooms
  - Garages
  - Double facades
- Roof to wall intersection
  - Separation of building and vented attics
- Fenestration connection to opaque wall / roof
- Soffits, “wings” and canopies connected to building
- Weatherstripping
- HVAC system leakage
  - Stuck dampers, non-adjusted dampers, leaky dampers
  - Damperless exhausts - kitchen hoods, bathroom exhausts
  - Utility tunnel closures in building sometimes non-existent
  - Utility, chimney and pipe wall and roof penetrations unsealed.

Thank you!

Questions?