

**AIVC Conference**

**Session 6: Case Studies of Two Whole-Building Air Leakage Tests**

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## **Presentation Objectives**

- Learn contemporary whole-building airtightness code requirements, industry standards, and guidelines.
- Understand the differences between qualitative and quantitative whole-building air leakage testing, the purpose of each, and governing ASTM standards.
- Understand how to effectively performing whole-building air leakage testing on new buildings and high-rise construction and analyze the results.

## **Presentation Outline**

- **Why Test?**
- **Code Requirements for Whole-Building Airtightness and Industry Standards / Guides**
- **Field Testing Standards**
- **Case Studies of Field Testing**

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## Why Test?

- **Air leakage in a real building is essentially impossible to determine analytically**
  - Complexity
  - Workmanship
  - Unique buildings / lack of data
- **Air leakage data is important for**
  - Energy calculations (identify air infiltration/exfiltration at low pressures)
  - Mechanical system design
  - Forensic analysis
  - Compliance with an airtightness specification or regulation
- **Repair costs for a failed air barrier are prohibitively high**
- **Repairs are only effective by removing cladding**

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## 2012 IECC – New Requirement for Air Barriers

### C402.4.1.2 Air Barrier Compliance Options

- Requires a continuous air barrier for the opaque building envelope.
- Three compliance paths:
  1. Building Air Leakage Test
    - Leakage rate through the envelope not to exceed 0.4 cfm/ft<sup>2</sup> at 0.3 in. water (75 Pa) per ASTM E779.
  2. Approved Assembly
    - CMU coated with block filler & two coats of paint or a sealer coating
    - Portland cement/sand parge and 1/2 in. stucco or plaster
      - Joints sealed
  3. Approved Materials
    - Joints are sealed and installed per manufacturer's instructions
    - Less than 0.004 cfm/ft<sup>2</sup> air leakage at 0.3 in. water (75 Pa).

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## Definitions

- An air barrier material is a primary element that provides a continuous barrier to the movement of air

- Self adhered membrane
- Fluid applied membrane
- Rigid sheathing

## Other Approved Air Barrier Materials:

1. Plywood—minimum 3/8 in.
2. Oriented strand board—minimum 3/8 in.
3. Extruded polystyrene insulation board—minimum 1/2 in.
4. Foil-faced urethane insulation board—minimum 1/2 in.
5. Exterior gypsum sheathing or interior gypsum board—minimum 1/2 in.
6. Cement board—minimum 1/2 in.
7. Built up roofing membrane
8. Modified bituminous *roof* membrane
9. Fully adhered single-ply *roof* membrane
10. A Portland cement/sand parge, stucco, or gypsum plaster—minimum 1/2 in. thick
11. Cast-in-place and precast concrete.
12. Sheet metal.
13. Closed cell 2 lb/ft<sup>3</sup> nominal density spray polyurethane foam—minimum 1 in.

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## US States Requiring Air Barriers in Energy Code

- Many states are requiring continuous air barriers in all commercial buildings.



- ...the list of states requiring air barriers is growing.

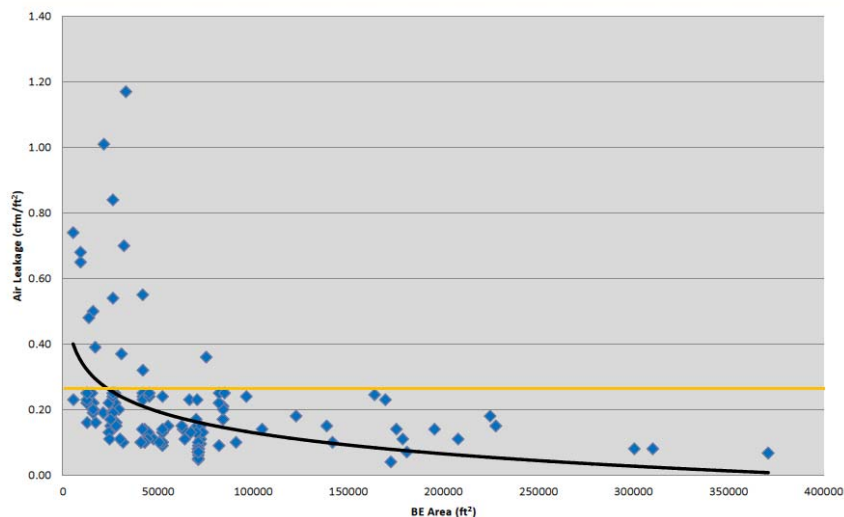
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## Other Standards / Guides

- **ASHRAE 90.1-2010**
  - The building envelope requires a continuous air barrier.
- **Air Barrier Association of America (ABAA)**
  - 0.40 cfm/ft<sup>2</sup> under a pressure differential of 0.3 in. water (75 Pa)
- **U.S. Army Corps of Engineers**
  - 0.25 cfm/ft<sup>2</sup> under a pressure differential of 0.3 in. water (75 Pa)
  - Recent studies show that buildings meet or exceed this criteria.

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## Measured Data – US Army Corp Leakage Rate vs. Building Size



Source: J. Durston, M. Heron – Summary & Analysis of  
Large Building Air Leakage Testing for USDOD

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## Presentation Outline

- Why Test?
- Code Requirements and Industry Standards / Guides
- **Field Testing Standards**
- Case Studies of Field Testing
  - Quantitative
  - Qualitative

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## Field Air Leakage Testing – Qualitative

- ASTM E1186 “Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems”
  - **Purpose: Identify locations of air barrier breaches**
  - Impose pressure differential (min. 20 Pa) on building to improve visualization of air leakage using:
    - Infrared thermography
    - Tracer smoke
    - Airflow measuring devices (anemometer), tracer gas, sound detection, leak detection liquid, other methods
- Make probe openings to verify findings (not req. by standard)

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## Field Air Leakage Testing – Quantitative

### “Blower Door Testing”

- ASTM E779 “Standard Test Method for Determining Air Leakage Rate by Fan Pressurization”
- **Purpose: Quantifies air leakage rate through building enclosure (CFM/ft<sup>2</sup>).**
- Use blower doors (i.e. fans) to determine relationship between building pressure and leakage.
- Limitations: This test does not identify air barrier breaches. Designed for simple detached buildings (single-zone).



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## Whole Building Air Leakage Case Studies

- High-Rise Residential Tower, Northeast US (June 2012)
- New Art Museum, Northeast US (July 2012)

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## Case Study #1 - High-Rise Residential Tower

- 16 story dorm built in 1960's
- Brick veneer with CMU-backup, 1 in. XPS insulation in cavity, and EPDM roof.
- Steel framed, monolithic glass windows (operable casement and fixed sash)



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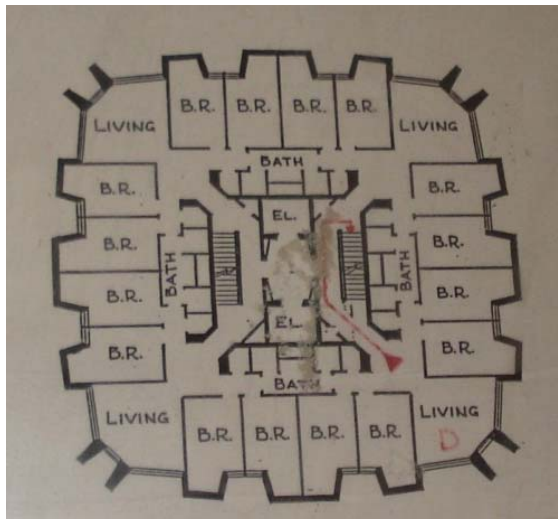
## High-Rise Residential Tower - Test Preparation



- Turn off mechanical equipment
- Air seal envelope penetrations and partitions

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## High-Rise Residential Tower - Test Preparation

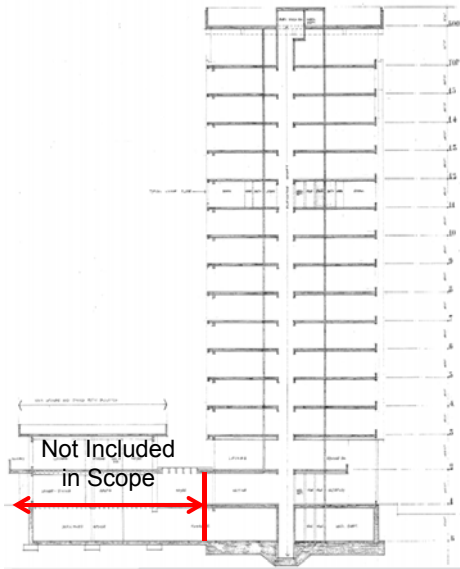


- Prop open doors (~450)
- Fill P-traps with water



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## Case Study #1 - High-Rise Residential Tower



Challenges of performing a single zone test:

- Zone separation
- Fan location
- Stack effects

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## High-Rise Residential Tower - Equipment Layout

- 12 blower door fans
  - 1<sup>st</sup> and 16<sup>th</sup> Floor Doors
  - 2<sup>nd</sup>, 7<sup>th</sup>, 10<sup>th</sup>, and 13<sup>th</sup> Floor Windows
- 12 DG-700 Pressure Gauges
  - 6 Control Fan Speed Controllers
  - 2 Measure Envelope Pressures
  - 4 Measure Interzonal Pressures



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## High-Rise Residential Tower - Typical Window Setup

- Omni-directional exterior pressure taps to measure envelope pressure
- Window frames designed and built in-house.



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## High-Rise Residential Tower - Test Procedure

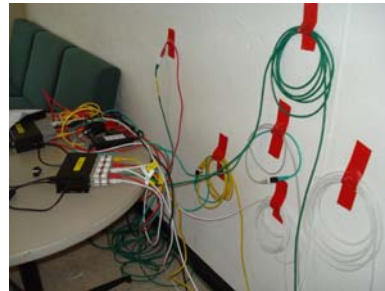
Perform negative and positive building pressurization.

Begin each test with all fans sealed (0 CFM).

Specify target pressure. Automated software regulates fan speeds to achieve target pressure.

Unseal fans as necessary to increase air flow to meet target pressures.

End each test with all fans sealed (0 CFM).



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## High-Rise Residential Tower - Test Results

- Setup: 6 staff / 2 days
- Execution: 7 staff / 2 hours
- Maximum building pressure:

Test	Air Leakage (CFM)	Air Leakage Rate (CFM/sq. ft.) @ 75 Pa
Pressurization	37250	0.88
Depressurization	33000	0.77

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## High-Rise Residential Tower - Smoke Test

- Tested 2<sup>nd</sup> floor office, typical dorm room, and 15<sup>th</sup> floor classroom.
- Air leakage was primarily through the steel framed, monolithic glass windows.



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## Case Study #2 - New Art Museum

- Two-story art museum completed in 2012
- Precast concrete, terra cotta, and curtain wall cladding systems with self-adhered AVB membrane



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## New Art Museum - Test Preparation



- Assumed a 0.40 cfm/sq. ft. air leakage rate → 4 fans
- Limited time frame for air leakage testing
- Curtain wall, overhead door not installed.

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## New Art Museum - Test Preparation

- Contractor installed temporary stud walls at construction openings and sealed openings with polyethylene sheets.
- Air sealed around temporary walls, basement area way, roof penetrations, roof vents, and basement door.



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## New Art Museum - Test Results

- The building enclosure airtightness exceeded the current industry standards.
- Setup: 5 staff / 1/2 day
- Execution: 5 staff / 2 hours

Test	Air Leakage (CFM)	Air Leakage Rate (CFM/sq. ft.) @ 75 Pa
Pressurization	3200	0.1
Depressurization	3900	0.12

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## New Art Museum - Smoke Test

- Performed smoke testing and observed multiple locations of air barrier leaks.



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## New Art Museum - Key Takeaways

- Smoke testing allowed contractor to observe air leakage sources firsthand.
- Construction progress and sequencing of air test will dictate significance of air test results.
- Communication with architect, owner, and contractor about schedule is paramount.



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## Key Takeways

- State energy codes are beginning to require continuous air barriers and whole-building testing
- Air testing is becoming more common
  - New buildings with air barriers can meet code requirements
- Incorporate whole-building tests in project specifications and coordinate with project team
- Value of quality control through qualitative testing

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**Thank you for your time.**

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