Air Barriers the Lost Chapter: Performance and Evaluation

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AIA CES - COURSE DESCRIPTION

We will explore the air barrier requirements in model building codes and standards referenced in the US and Canada, address misconceptions, and will work to outline a framework for a path forward to improve these documents. Beginning with a brief history of air barriers in model codes and standards, we will review the requirements of the 2018 IECC and the 90.1-2016 as well as changes from their earlier versions. We will then briefly explore the differences between whole building test methods and their impact on our understanding of in situ performance.
The presentation will conclude with a discussion of the various modeling tools and opportunities to improve the evaluation of the impact of airtightness on projected energy savings of projects in design.

AIA CES - LEARNING OBJECTIVES

Upon completing the course participants will be able to:

1. Describe the various model code and standard requirements for air barriers in North America.
2. Describe the various protocols for compliance for materials, assemblies, and whole buildings and how these differ between codes.
3. Discuss impacts of airtightness on energy modeling results, including the strengths and weaknesses of the results.
4. Discuss the future possibilities for code and standard development for air barriers.

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AUDIENCE SURVEY

1. Who's in the audience (OAC)?
2. Who has specified or participated in a whole building airtightness test?
3. …any not required by code?

AIR BARRIER THE LOST CHAPTER:
UNDERSTANDING AIR BARRIER PERFORMANCE AND EVALUATION

01

THE BUILDING ENCLOSURE

AIR BARRIER THE LOST CHAPTER

THE BUILDING ENCLOSURE

Shelter

Aesthetics

Security

Energy & Comfort

Durability

Serviceability

THE BUILDING ENCLOSURE

Complex

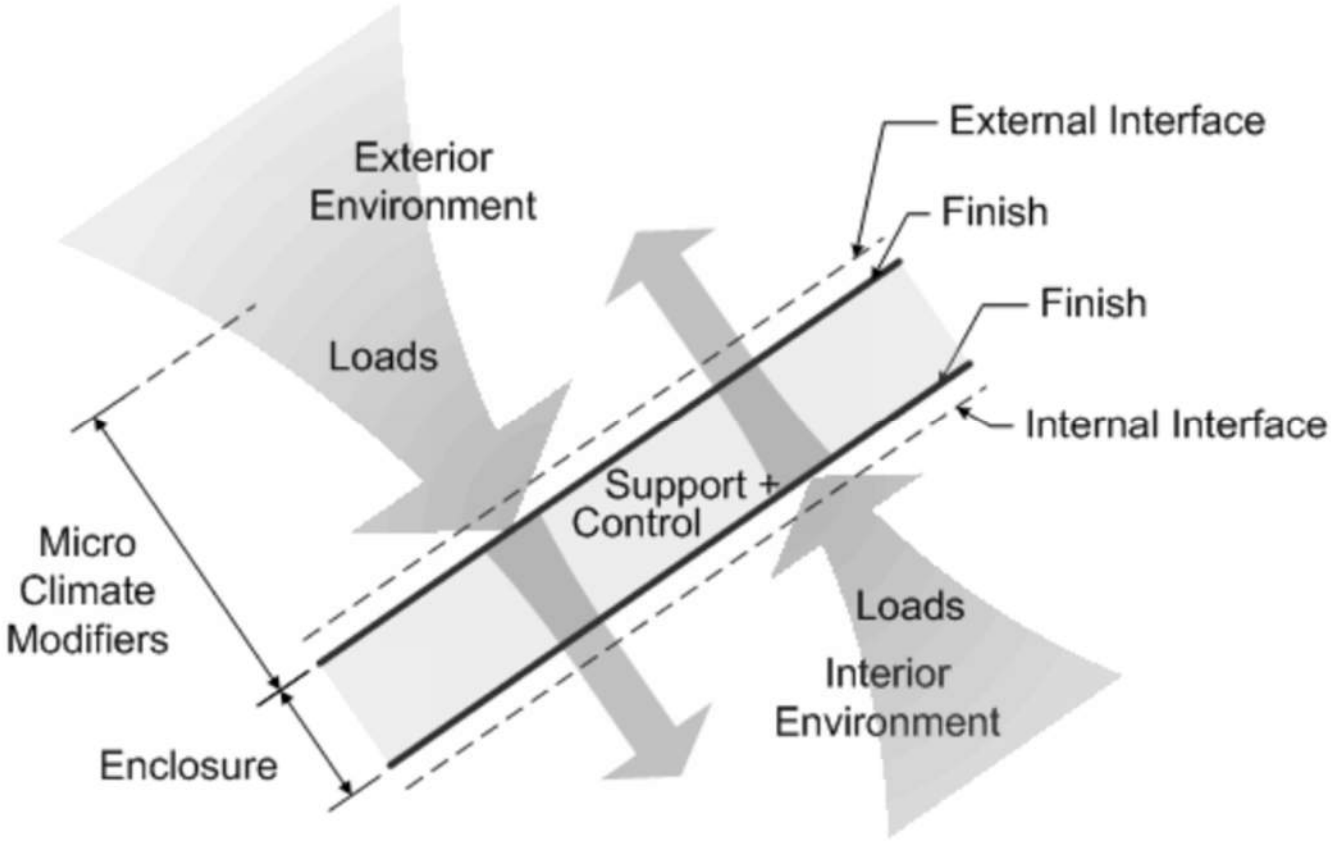
Simple

THE BUILDING ENCLOSURE

The primary function of the building enclosure is to separate environmental conditions – Interior from the exterior OR interior to interior – and typically include the following components:

- Roof
- Above-Grade Walls
- Fenestration (Windows, Doors, Louvers)
- Below-Grade Walls
- Slab-on-Grade or Exposed Floor Systems

THE BUILDING ENCLOSURE



THE BUILDING ENCLOSURE

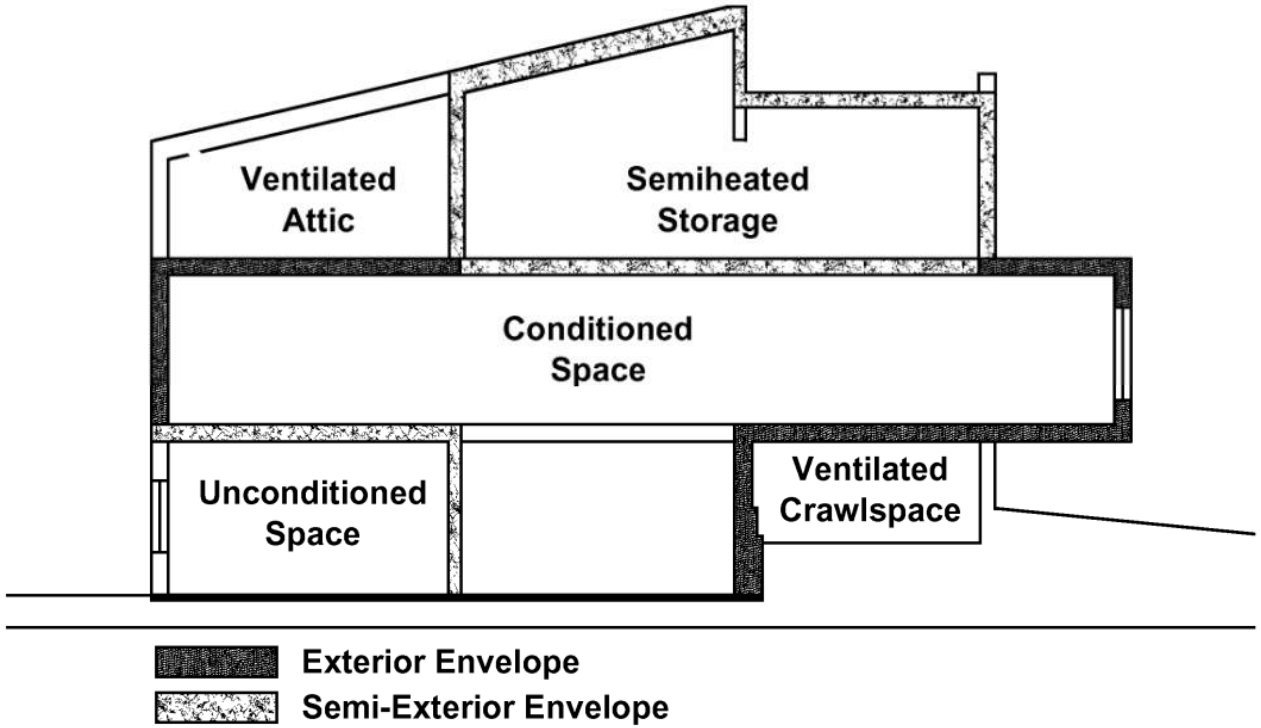
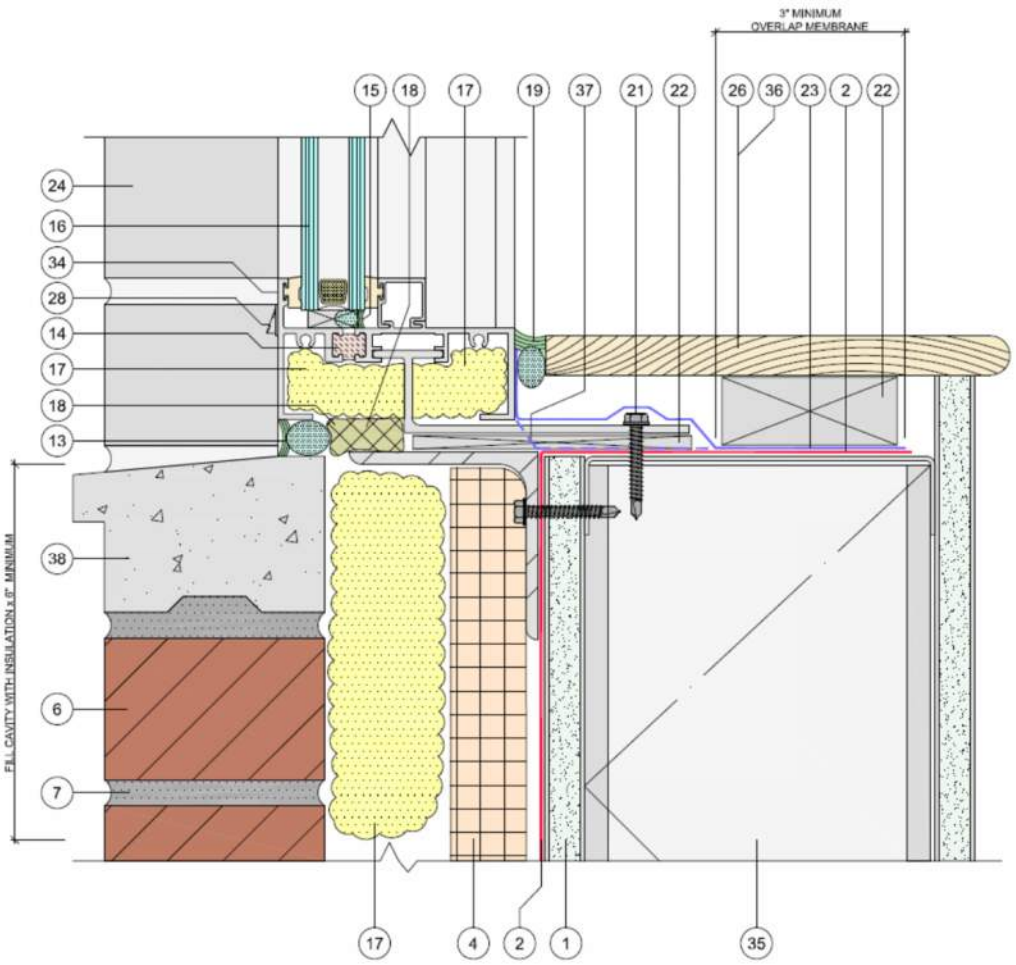


Figure 5.5.2 Exterior and *semiexterior building envelope*.

ASHRAE 90.1-2016

THE BUILDING ENCLOSURE

Today's Building Enclosure



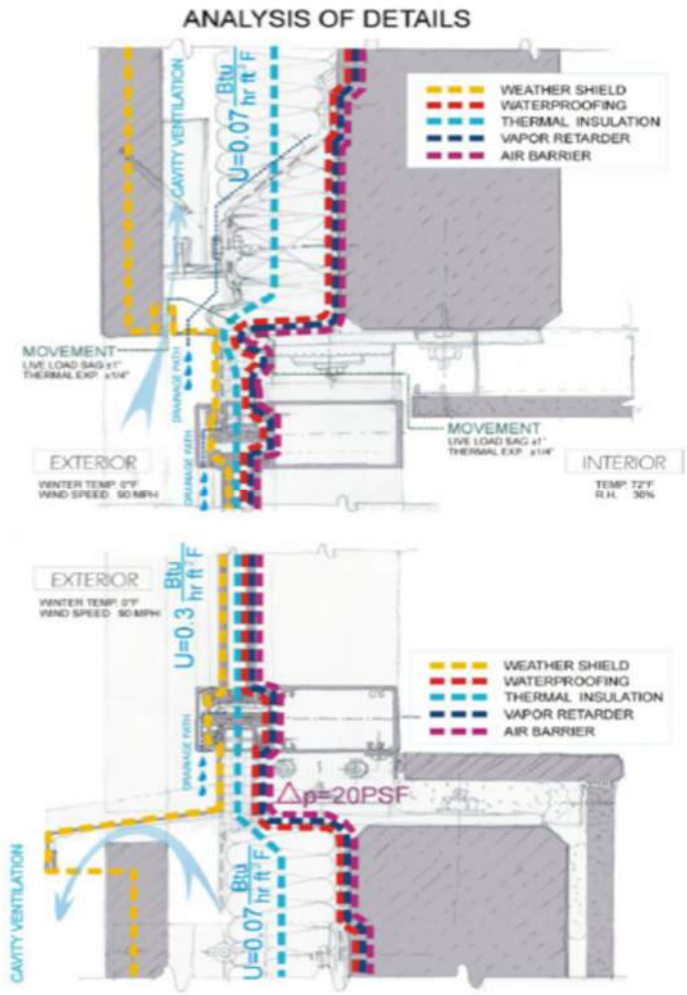
C WINDOW SILL AT BRICK VENEER
GENERIC CONDITION

THE BUILDING ENCLOSURE

Control Layers

Building Enclosures are designed to control multiple loadings this presentation will primarily be concerned with the following in order of importance:

1. Water Control Layer
2. Air Control Layer
3. Vapor Control Layer
4. Thermal Control Layer



THE BUILDING ENCLOSURE

Water Control Layer (Priority 1)

The continuous layer (comprised of one of several materials and formed into planes to form a three dimensional boundary) that is designed, installed, or acts to control the passage of liquid water even after long or continuous exposure to moisture.

- Interconnected with flashings, window and door openings, and other penetrations
- Overlap each other shingle fashion or are sealed so that water flow is downward and outward.
- Goal is to evacuate water from the assembly and away from the building as quickly as reasonably possible.

THE BUILDING ENCLOSURE

Air Control Layer (Priority 2)

Three-dimensional systems of materials designed, constructed, and/or acting to control air flow across a building enclosure, or between a conditioned space and an unconditioned space. The pressure boundary of the enclosure should, by definition, be coincident with the plane of a functional air control layer system.

- Interconnected with flashings, window and door openings, and other penetrations
- Continuity is Critical
- Moisture-Laden-Airflow can carry 100 to 300x's more moisture than diffusion over the same time period

THE BUILDING ENCLOSURE

Vapor Control Layer (Priority 3)

The component or components that are designed and installed in an assembly to control the movement of water by vapor diffusion.

- Vapor diffusion is a linear process of moisture transport through a material
- “Continuity” of a Vapor Control Layer may be significantly dis-continuous (10% +) and still perform as a vapor control.

THE BUILDING ENCLOSURE

Thermal Control Layer (Priority 4)

The component or components that are designed and installed in an assembly to control the transfer of thermal energy (heat). Typically these are comprised of insulation products, radiant barriers, or trapped gaps filled with air or other gases.

- Interrupted by flashings, window and door openings, and other penetrations
- Understand the Impact of Thermal Bridging (see ASHRAE 90.1-Appendix A)

THE BUILDING ENCLOSURE

Historic Building Enclosure

- Simpler building systems
- Fewer layers
- Master tradesmen
- Apprenticeship training
- Lower Expectations?

https://en.wikipedia.org/wiki/Old_Stone_House_(Washington,_D.C.)#/media/File:Old_Stone_House_-_ca._1890.jpg

THE BUILDING ENCLOSURE

Today's Building Enclosure

- Complex building materials
- Multi-layer construction / multiple trades
- Thinner construction
- Limited on-the-job training
- Higher expectations
- Schedule Critical
- Cost Sensitive

http://www.mgac.com/projects/house-of-sweden/33

THE BUILDING ENCLOSURE

Why the Building Enclosure

- Risk/Lost/Delay Mitigation
- Avoid Failure/Lawsuit
- Occupant Comfort/Indoor Environmental Quality (IEQ)
- Load Reduction/Energy Efficiency
- Chemical, Biological, Radiological (CBR) Security
- Blast Resistance
- Maintenance and Serviceability

02

AIR CONTROL:
A BRIEF HISTORY IN CODE

AIR BARIER THE LOST CHAPTER

CONTINUOUS AIR BARRIER: A BRIEF HISTORY IN MODEL CODE

1985 National Building Code of Canada requires air barriers

- Late 1980's research and seminal papers + industry education
- Focus on Durability and Comfort Concerns

2000 England required whole building air leakage testing

2001 Massachusetts Energy Code

- Air barrier requirements and compartmentalization
- Research and education campaign

2001 ABAA Formed for regulation and education

2005 NIST Air Tightness Study for 90.1, incorporated in 2010 edition

CONTINUOUS AIR BARRIER: A BRIEF HISTORY IN MODEL CODE

2009 USACE Air Tightness Protocol

- 0.25 cfm/sqft at 75 Pa

2010 GSA PBS P-100 Requires Whole Building Air Leakage Testing

- 0.40 cfm/sqft @75 Pa

2012 IECC includes Whole Building Air Leakage Testing Option

- 0.40 cfm/sqft @75 Pa

2012 IgCC Requires Whole Building Air Leakage Testing

- 0.25 cfm/sqft at 75 Pa
- BECx Option

CONTINUOUS AIR BARRIER: A BRIEF HISTORY IN MODEL CODE

2012 Washington State Building Code Requires Whole Building Testing

- 0.40 cfm/sqft at 75 Pa
- BECx Option

2015 Seattle Energy Code Requires Whole Building Testing

- 0.30 cfm/sqft at 75 Pa

2015 Utah DFCM HPBS Requires Whole Building Testing

- 0.10 cfm/sqft at 75 Pa
- BECx Required

CONTINUOUS AIR BARRIER: A BRIEF HISTORY IN MODEL CODE

2016 ASHRAE 90.1-2016 Requires Whole Building Air Leakage Testing

- 0.40 cfm/sqft at 75 Pa
- BECx Option (Design Review + On Site Observations)

03

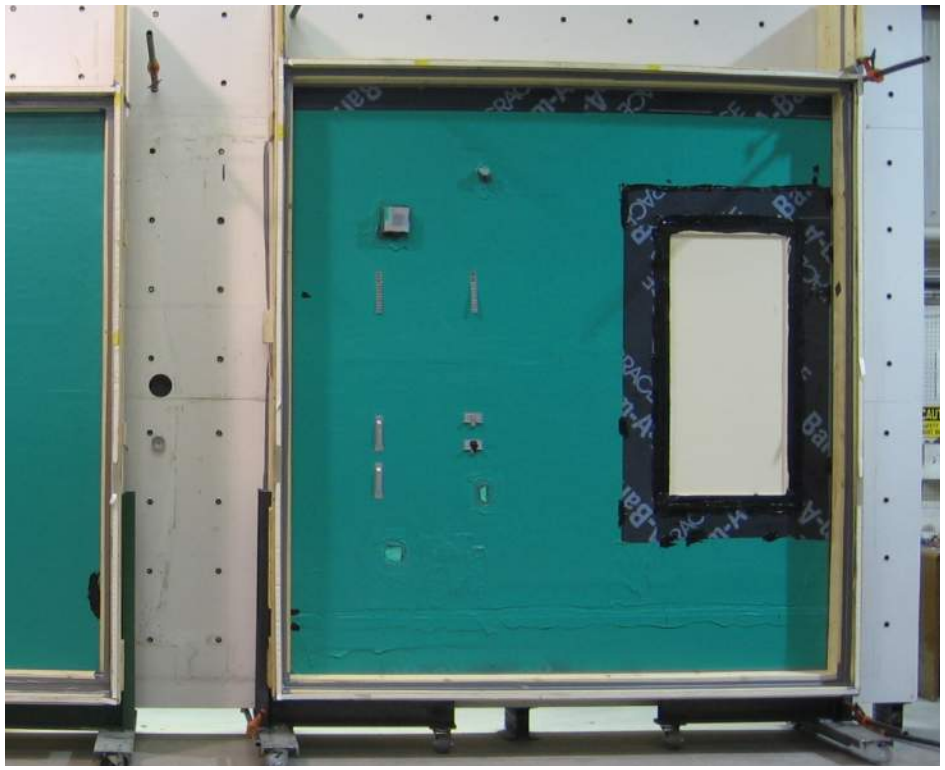
MATERIALS, ASSEMBLIES, AND THE WHOLE BUILDING

MATERIALS

ASTM E2178

- < 0.004 cfm/ft2 75 Pa
- Material Only
- No detailing or transitions
- No impact of weather or site conditions

ASSEMBLIES

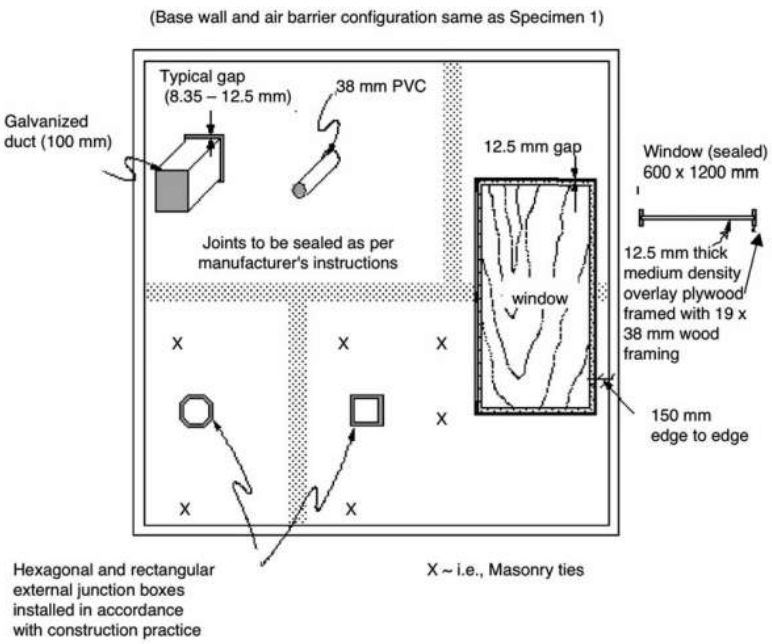


ASTM E2357*

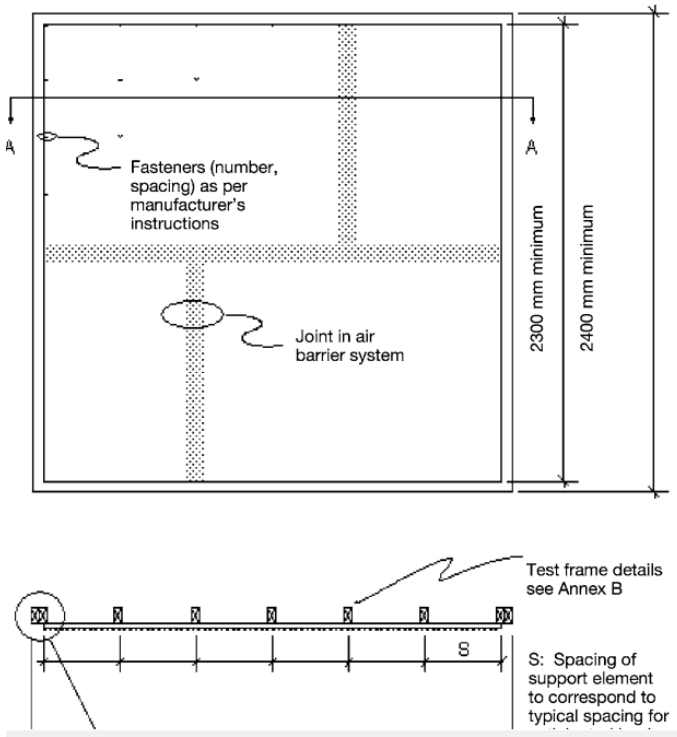
- < 0.040 cfm/ft2 75 Pa
- Structural loading
- Simulated Window
- Detailing included
- No interface details
- No impact of weather or site conditions

ASSEMBLIES

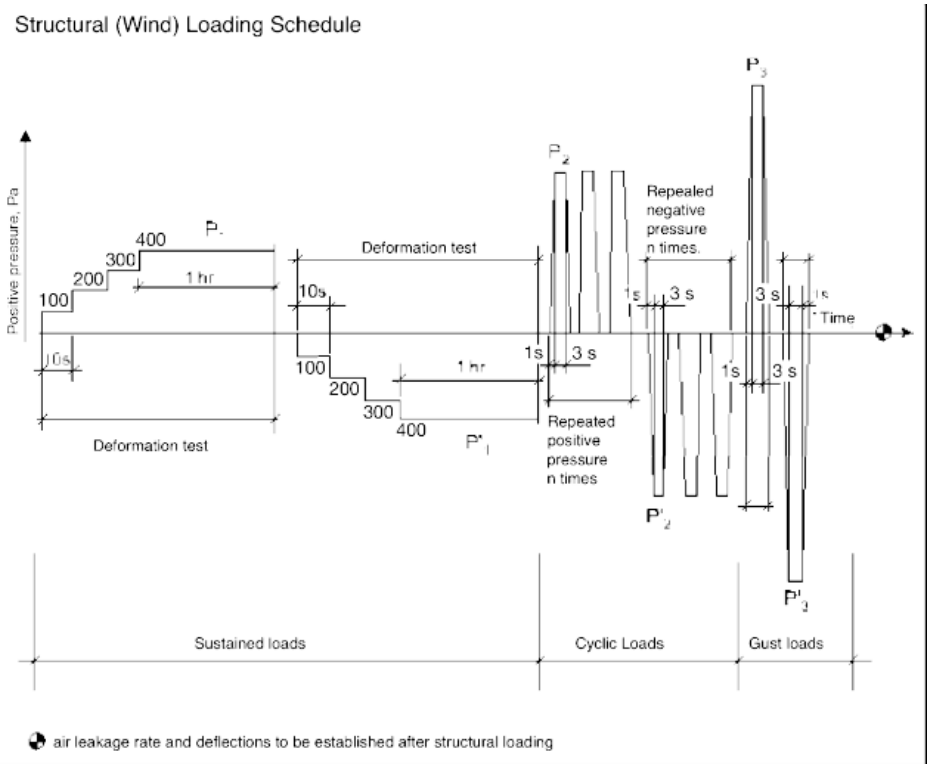
Specimen 2 – Continuity at Penetrations



Specimen 1 - Opaque Wall



ASSEMBLIES



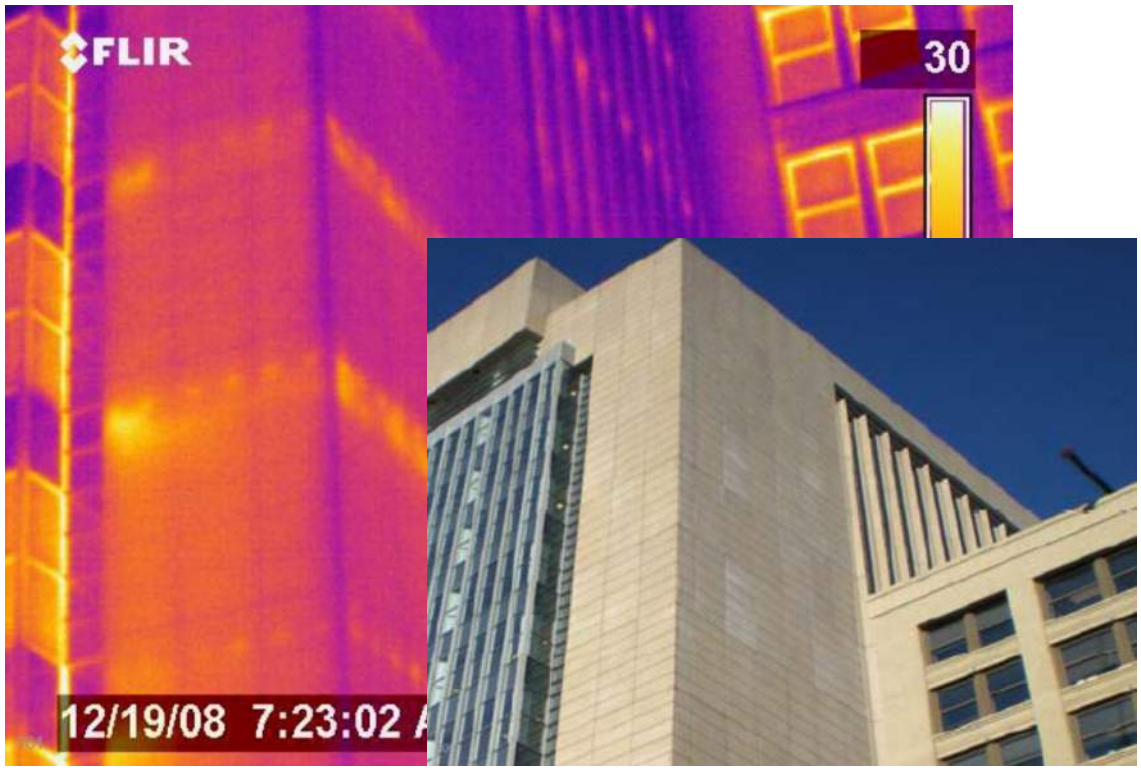
ASTM E2357 includes
<u>Structural loading</u>

WHOLE BUILDINGS

ASTM E779

- <0.400 cfm/ft2 75 Pa
- Real Construction
- Detailing included
- Transitions Included
- Actual Construction

WHOLE BUILDINGS



ASTM E779

- <0.400 cfm/ft2 75 Pa
- Real Construction
- Detailing included
- Transitions Included
- Actual Construction

WHOLE BUILDINGS

ASTM E779

- <0.400 cfm/ft2 75 Pa
- Real Construction
- Detailing included
- Transitions Included
- Actual Construction

MATERIALS, ASSEMBLIES, AND THE WHOLE BUILDING

Materials

- ASTM E2178+
- 0.004 cfm/ft^2 (75 Pa)

Testing of air barrier materials is necessary but not sufficient to obtain performance.

Assemblies

- ASTM E2357+
- 0.04 cfm/ft^2 (75 Pa)

Testing of assemblies is essential to demonstrate performance of designed assembly.

Whole Building

- ASTM E779+
- 0.40 cfm/ft^2 (75 Pa)

Only assessment of installed performance, including materials, assemblies, and complete systems.

THE BUILDING ENCLOSURE

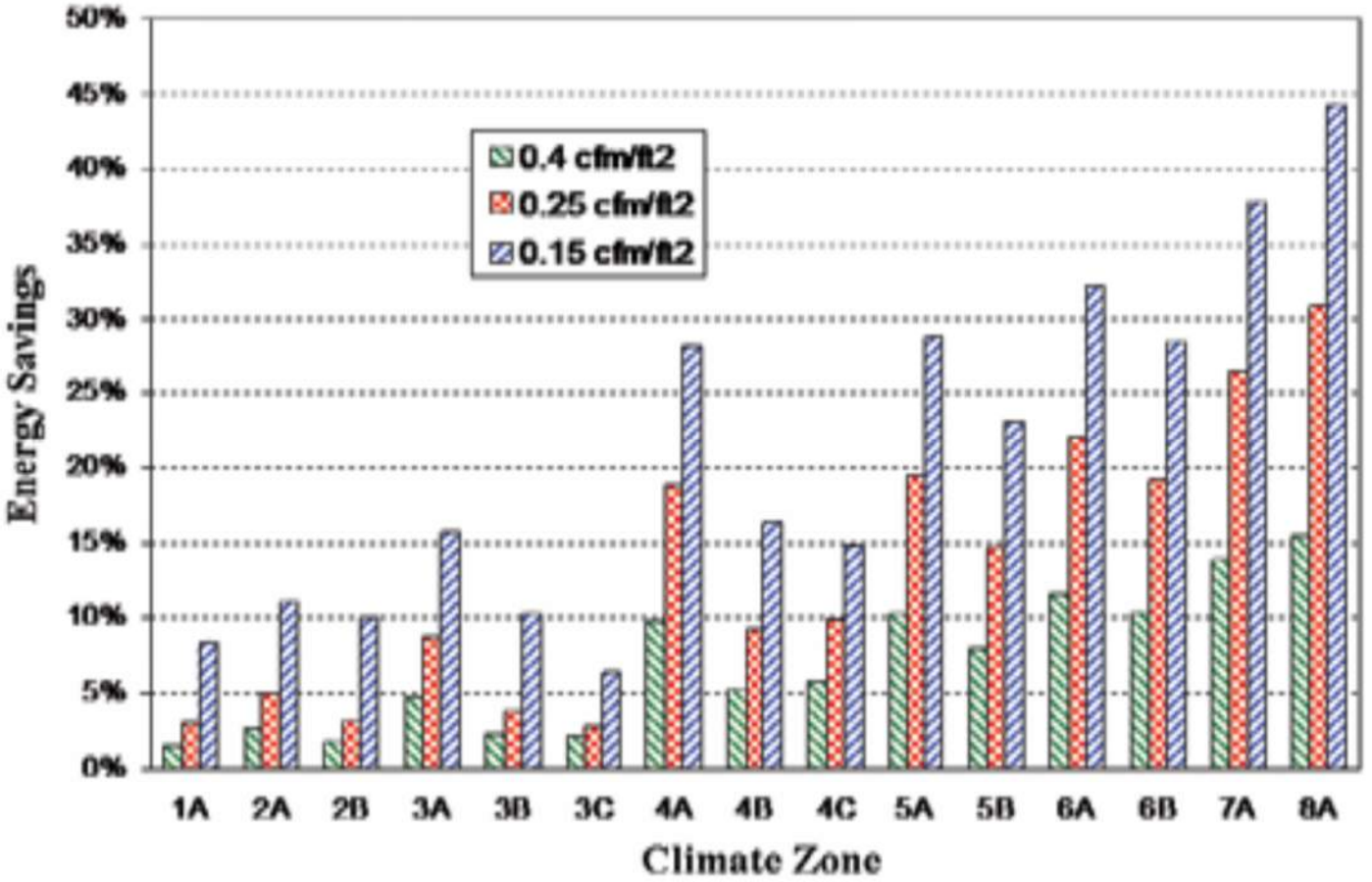
Air Infiltration Requirements cfm/ft² @ 0.3 in w.g. (75 Pa)	**Materials** (ASTM E2178 or CAN/ULC-S741)		**Assemblies** (ASTM E2357/ CAN/ULC-S742, or E1677)		**Whole Building** (ASTM E779 or CAN/CGSB 149.15)
ASHRAE 90.1 (2016)	**0.004**	***or***	**0.04**	***AND***	**0.40***
USACE(2008); **NAVFAC** (2011)	**0.004**		**--**	***AND***	**0.25**
Washington State (2010)	**0.004**		**--**	***AND***	**0.40**
Seattle (2015)	**0.004**		**--**	***AND***	**0.30**
GSA (2010) **USAF** (2011)	**0.004**	***or***	**0.04**	***AND***	**0.40**
IECC (2012)	**0.004**	***or***	**0.04**	***or***	**0.40**
IgCC (2012)	**--**		**--**		**0.25**
State of Utah (2015)	**0.004**		**0.04**	***AND***	**0.10**

*BECx provided as an alternate Compliance path

DESIGN AND INSTALLATION

- Continuous air barrier identified in design
- Continuous on entire enclosure (Thermal envelope/Conditioned space)
- Seal joints and interfaces
- Resist positive and negative wind pressures

MATERIALS, ASSEMBLIES, AND THE WHOLE BUILDING



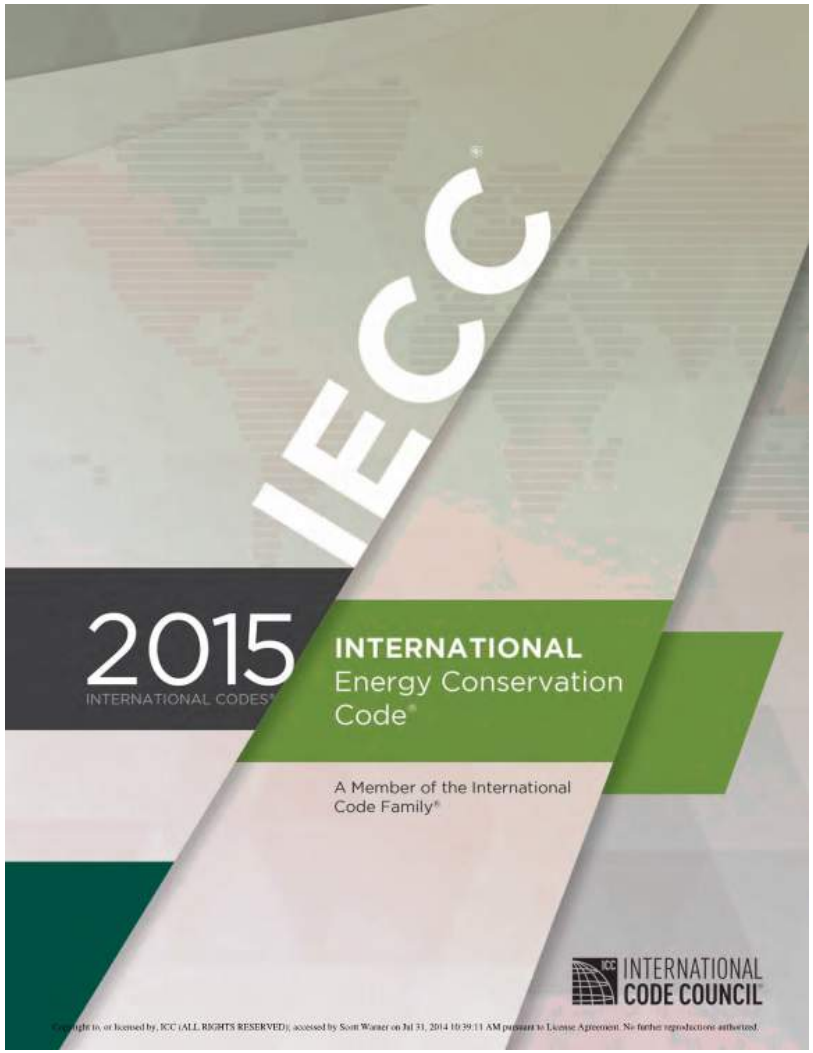
Credit: Journal of Building Enclosure Design Summer 2011 "Improvement of Air Tightness in U.S. Army Buildings" pgs. 11-13

04

MODEL CODES:
2015 IECC & 90.1-2016

Continuous Air Barriers:
When is Code “Good Enough”?

2015 IECC


IECC
2015
INTERNATIONAL CODES
INTERNATIONAL
Energy Conservation
Code
A Member of the International
Code Family
INTERNATIONAL
CODE COUNCIL

2015 IECC
MATERIALS, ASSEMBLIES, OR WHOLE BUILDING

C402.5 Air leakage—thermal envelope (Mandatory). The *thermal envelope* of buildings shall comply with Sections C402.5.1 through C402.5.8, or the building *thermal envelope* shall be tested in accordance with ASTM E 779 at a pressure differential of 0.3 inch water gauge (75 Pa) or an equivalent method approved by the code official and deemed to comply with the provisions of this section when the tested air leakage rate of the building thermal envelope is not greater than 0.40 cfm/ft^2 (0.2 L/s · m^2). Where compliance is based on such testing, the building shall also comply with Sections C402.5.5, C402.5.6 and C402.5.7.

C402.5.1 Air barriers. A continuous air barrier shall be provided throughout the building thermal envelope. The air barriers shall be permitted to be located on the inside or outside of the building envelope, located within the assemblies composing the envelope, or any combination thereof. The air barrier shall comply with Sections C402.5.1.1 and C402.5.1.2.

Exception: Air barriers are not required in buildings located in *Climate Zone* 2B.

2015 IECC
DESIGN & INSTALLATION

C402.5.1.1 Air barrier construction. The *continuous air barrier* shall be constructed to comply with the following:

1. The air barrier shall be continuous for all assemblies that are the thermal envelope of the building and across the joints and assemblies.
2. Air barrier joints and seams shall be sealed, including sealing transitions in places and changes in materials. The joints and seals shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair its ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation.
3. Penetrations of the air barrier shall be caulked, gasketed or otherwise sealed in a manner compatible with the construction materials and location. Joints and seals associated with penetrations shall be sealed in the same manner or taped or covered with moisture vapor-permeable wrapping material. Sealing materials shall be appropriate to the construction materials being sealed and shall be securely installed around the penetration so as not to dislodge, loosen or otherwise impair the penetrations' ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation. Sealing of concealed fire sprinklers, where required, shall be in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.
4. Recessed lighting fixtures shall comply with Section C402.5.7. Where similar objects are installed that penetrate the air barrier, provisions shall be made to maintain the integrity of the air barrier.

2015 IECC
MATERIALS, ASSEMBLIES, OR WHOLE BUILDING

C402.5.1.2 Air barrier compliance options. A continuous air barrier for the opaque building envelope shall comply with Section C402.5.1.2.1 or C402.5.1.2.2.

C402.5.1.2.1 Materials. Materials with an air permeability not greater than 0.004 cfm/ft^2 (0.02 L/s · m^2) under a pressure differential of 0.3 inch water gauge (75 Pa) when tested in accordance with ASTM E 2178 shall comply with this section. Materials in Items 1 through 16 shall be deemed to comply with this section, provided joints are sealed and materials are installed as air barriers in accordance with the manufacturer's instructions.

C402.5.1.2.2 Assemblies. Assemblies of materials and components with an average air leakage not greater than 0.04 cfm/ft^2 (0.2 L/s · m^2) under a pressure differential of 0.3 inch of water gauge (w.g.)(75 Pa) when tested in accordance with ASTM E 2357, ASTM E 1677 or ASTM E 283 shall comply with this section. Assemblies listed in Items 1 through 3 shall be deemed to comply, provided joints are sealed and the requirements of Section C402.5.1.1 are met.

2015 IECC
MATERIALS, ASSEMBLIES, OR WHOLE BUILDING

C402.5.1.2.1 Materials. Materials with an air permeability not greater than 0.004 cfm/ft^2 (0.02 L/s · m^2) under a pressure differential of 0.3 inch water gauge (75 Pa) when tested in accordance with ASTM E 2178 shall comply with this section. Materials in Items 1 through 16 shall be deemed to comply with this section, provided joints are sealed and materials are installed as air barriers in accordance with the manufacturer's instructions.

1. Plywood with a thickness of not less than $^3/_8$ inch (10 mm).
2. Oriented strand board having a thickness of not less than $^3/_8$ inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than $^1/_2$ inch (12.7 mm).
4. Foil-back polyisocyanurate insulation board having a thickness of not less than $^1/_2$ inch (12.7 mm).
5. Closed-cell spray foam a minimum density of 1.5 pcf (2.4 kg/m^3) having a thickness of not less than $1^1/_2$ inches (38 mm).
6. Open-cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m^3) and having a thickness of not less than 4.5 inches (113 mm).
7. Exterior or interior gypsum board having a thickness of not less than $^1/_2$ inch (12.7 mm).
8. Cement board having a thickness of not less than $^1/_2$ inch (12.7 mm).
9. Built-up roofing membrane.
10. Modified bituminous roof membrane.
11. Fully adhered single-ply roof membrane.
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than $^5/_8$ inch (15.9 mm).
13. Cast-in-place and precast concrete.
14. Fully grouted concrete block masonry.
15. Sheet steel or aluminum.
16. Solid or hollow masonry constructed of clay or shale masonry units.

2015 IECC
MATERIALS, ASSEMBLIES, OR WHOLE BUILDING

C402.5.1.2.2 Assemblies. Assemblies of materials and components with an average air leakage not greater than 0.04 cfm/ft^2 (0.2 L/s · m^2) under a pressure differential of 0.3 inch of water gauge (w.g.)(75 Pa) when tested in accordance with ASTM E 2357, ASTM E 1677 or ASTM E 283 shall comply with this section. Assemblies listed in Items 1 through 3 shall be deemed to comply, provided joints are sealed and the requirements of Section C402.5.1.1 are met.

1. Concrete masonry walls coated with either one application of block filler or two applications of a paint or sealer coating.
2. Masonry walls constructed of clay or shale masonry units with a nominal width of 4 inches (102 mm) or more.
3. A Portland cement/sand parge, stucco or plaster not less than $^1/_2$ inch (12.7 mm) in thickness.

ASHRAE 90.1 - 2016

STANDARD

ANSI/ASHRAE/IES Standard 90.1-2016
(Supersedes ANSI/ASHRAE/IES Standard 90.1-2013)
Includes ANSI/ASHRAE/IES addenda listed in Appendix H

Energy Standard for Buildings Except Low-Rise Residential Buildings
(I-P Edition)

See Appendix H for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the IES Board of Directors, and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

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ASHRAE 90.1 – 2016
DESIGN & INSTALLATION

5.4.3 Air Leakage

5.4.3.1 Continuous Air Barrier

The entire *building envelope* shall be designed and constructed with a *continuous air barrier*.

Exceptions to 5.4.3.1

1. *Semiheated spaces* in Climate Zones 0 through 6.
2. Single wythe concrete masonry *buildings* in Climate Zone 2B.

5.4.3.1.1 Continuous Air Barrier Design

The *continuous air barrier* shall be designed and noted in the following manner:

a. All air barrier components of each *building envelope* assembly shall be clearly identified or otherwise noted on *construction documents*.
b. The joints, interconnections, and penetrations of the *continuous air barrier* components, including lighting *fixtures*, shall be detailed or otherwise noted.
c. The *continuous air barrier* shall extend over all surfaces of the *building envelope* (at the lowest *floor*, *walls*, and *roof*).
d. The *continuous air barrier* shall be designed to resist positive and negative pressures from wind, stack effect, and mechanical *ventilation*.

5.4.3.1.2 Continuous Air Barrier Installation

The following areas of the *continuous air barrier* in the *building envelope* shall be wrapped, sealed, caulked, gasketed, or taped in an approved manner to minimize air leakage:

a. Joints around *fenestration* and *door* frames (both manufactured and site-built).
b. Junctions between *walls* and *floors*, between *walls* at *building* corners, and between *walls* and *roofs* or ceilings.
c. Penetrations through the *continuous air barrier* in *building envelope roofs*, *walls*, and *floors*.
d. *Building* assemblies used as ducts or plenums.
e. Joints, seams, connections between planes, and other changes in *continuous air barrier* materials.

ASHRAE 90.1 – 2016
MATERIALS, ASSEMBLIES, OR WHOLE BUILDING

5.4.3.1.3 Testing, Acceptable Materials, and Assemblies

The *building* shall comply with whole-*building* pressurization testing in accordance with Section 5.4.3.1.3(a) or with the *continuous air barrier* requirements in Section 5.4.3.1.3(b) or 5.4.3.1.3(c).

- 5.4.3.1.3(a) = Materials
- 5.4.3.1.3(b) = Assemblies
- 5.4.3.1.3(c) = Whole Building

b. Materials that have an air permeance not exceeding 0.004 cfm/ft^2 under a pressure differential of 0.3 in. of water (1.57 psf) when tested in accordance with ASTM E2178. The following materials meet these requirements:

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. 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^3 nominal density spray polyurethane foam—minimum 1 in.

ASHRAE 90.1 – 2016
VERIFICATION

5.9.2 Verification

5.9.2.1 Building Envelope Performance Verification

The performance of the *building envelope* shall be verified in accordance with this section and Section 4.2.5.

5.9.2.2 Air Leakage Verification

Air leakage verification shall be determined in accordance with one of the following methods:

a. An air barrier design and installation verification program shall be implemented and shall include the following elements:

   1. A design review shall be conducted to assess compliance with the requirements in Sections 5.4.3.1.1, 5.4.3.1.2, and the applicable portions of Section 5.4.3.1.3.
   2. Periodic field inspection of *continuous air barrier* components and assemblies shall be conducted during *construction* while the air barrier is still accessible for inspection and *repair* to verify compliance with the requirements of Sections 5.4.3.1.1, 5.4.3.1.2, and the applicable portions of Section 5.4.3.1.3.
   3. Reporting shall be in compliance with Section 4.2.5.

b. A whole-*building* air leakage verification program shall be implemented and shall include the following elements:

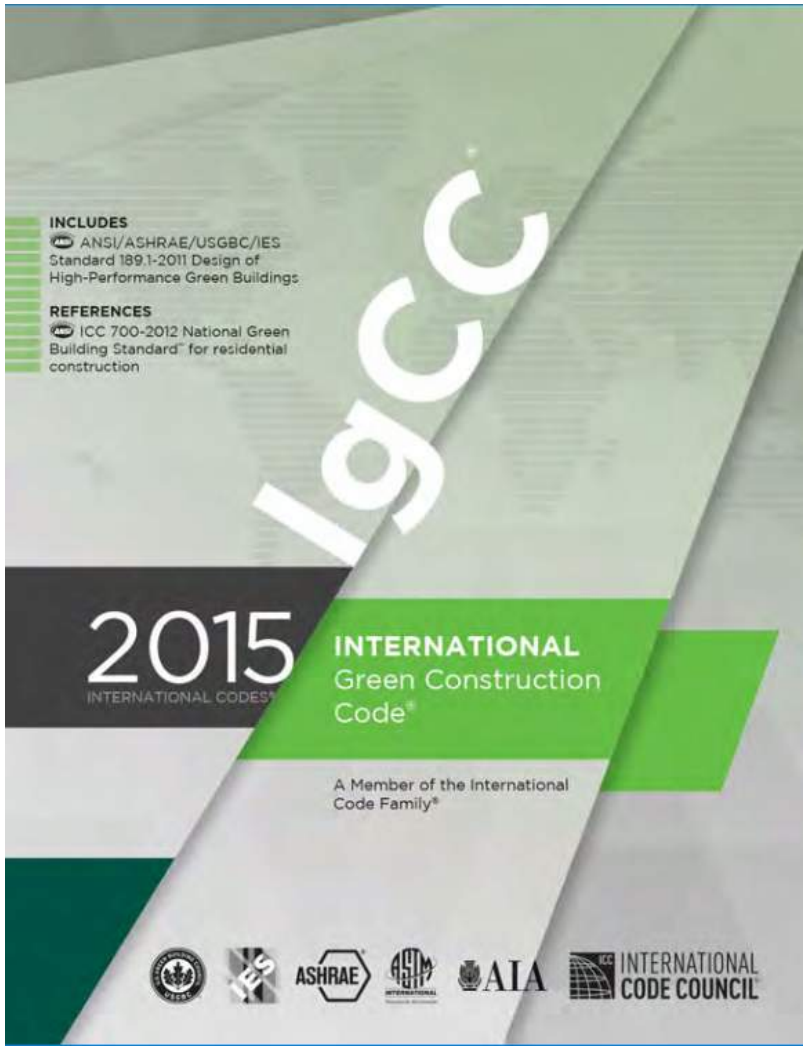
   1. Whole-*building* pressurization testing shall be performed in accordance with Section 5.4.3.1.3(a) and the use of any exceptions shall be documented.
   2. Reporting shall be in compliance with Section 4.2.5.

05

SUSTAINABILITY GOALS: 2015 IgCC, LEEDv4, & WELL

Continuous Air Barriers:
When is Code “Good Enough”?

2015 IgCC


INCLUDES
ANSI/ASHRAE/USGBC/IES Standard 189.1-2011 Design of High-Performance Green Buildings
REFERENCES
ICC 700-2012 National Green Building Standard™ for residential construction
IgCC
2015
INTERNATIONAL CODES
INTERNATIONAL
Green Construction Code®
A Member of the International Code Family®
ASHRAE
AIA
INTERNATIONAL CODE COUNCIL

2015 IgCC

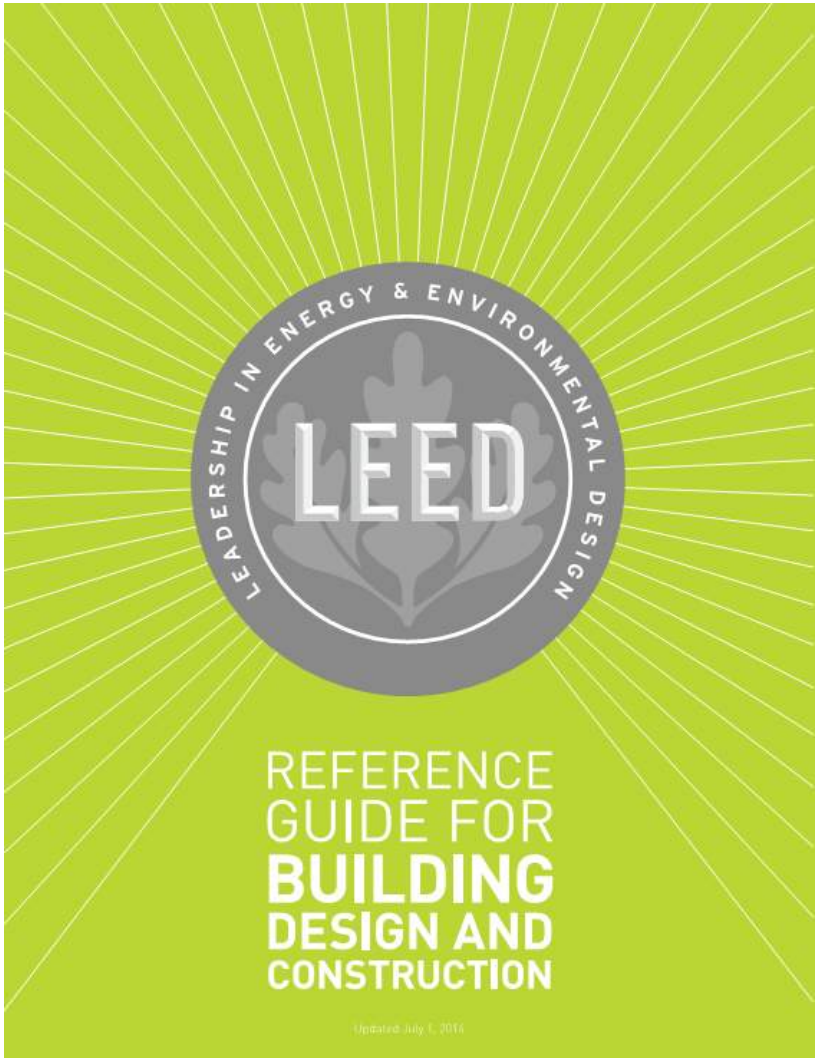
605.1.2 Air leakage. The *building thermal envelope* shall be durably sealed to limit air leakage in accordance with Section C402.4 of the *International Energy Conservation Code* and the provisions of this section.

605.1.2.1 Air barriers. A continuous air barrier shall be provided for buildings in *climate zones* 1 through 8 in accordance with Section C402.5.1 of the *International Energy Conservation Code*. The exception in Section C402.5.1 of the *International Energy Conservation Code* shall not apply.

605.1.2.2 Testing requirement. The *building thermal envelope* air tightness shall be tested and the air leakage rate of the total area of the *building thermal envelope* shall not exceed 0.25 cfm/ft^2 under a pressure differential of 0.3-inch water column (1.57 lb/ft^2) (1.25 L/s.m^2 under a pressure differential of 75 Pa). Testing shall occur after rough-in and after installation of penetrations of the building envelope, including penetrations for utilities, heating, ventilating and air-conditioning (HVAC) systems, plumbing, and electrical equipment and appliances. Testing shall be done in accordance with ASTM E779. A report that includes the tested surface area, floor area, air by volume, stories above grade, and leakage rates shall be submitted to the code official and the building owner. Where the tested rate exceeds 0.25 cfm/ft^2, a visual inspection of the air barrier shall be conducted and any leaks noted shall be sealed to the extent practicable. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the code official and the building owner, and shall be deemed to satisfy the requirements of this section.

605.1.2.3 Air curtains. Where air curtains are provided at building entrances or building entrance vestibules, the curtain shall have a minimum velocity of 2 m/s at the floor, be tested in accordance with ANSI/AMCA 220 and installed in accordance with the manufacturer's instructions. Manual or automatic controls shall be provided that will operate the air curtain with the opening and closing of the door. Air curtains and their controls shall comply with Section C408.2.3 of the *International Energy Conservation Code*.

LEED V4


LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN
LEED
REFERENCE GUIDE FOR BUILDING DESIGN AND CONSTRUCTION
Updated July 1, 2016

LEED V4

LEED V4

ENERGY AND ATMOSPHERE CREDIT

Optimize Energy Performance

This credit applies to:

New Construction (1–18 points)
Core and Shell (1–18 points)
Schools (1–16 points)
Retail (1–18 points)
Data Centers (1–18 points)
Warehouses and Distribution Centers (1–18 points)
Hospitality (1–18 points)
Healthcare (1–20 points)

INTENT

To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic harms associated with excessive energy use.

ENERGY AND ATMOSPHERE CREDIT

Enhanced Commissioning

This credit applies to:

New Construction (2-6 points)
Core and Shell (2-6 points)
Schools (2-6 points)
Retail (2-6 points)
Data Centers (2-6 points)
Warehouses and Distribution Centers (2-6 points)
Hospitality (2-6 points)
Healthcare (2-6 points)

OPTION 2. ENVELOPE COMMISSIONING (2 POINTS)

Fulfill the requirements in EA Prerequisite Fundamental Commissioning and Verification as they apply to the building's thermal envelope in addition to mechanical and electrical systems and assemblies.

Complete the following commissioning process (CxP) activities for the building's thermal envelope in accordance with ASHRAE Guideline 0–2005 and the National Institute of Building Sciences (NIBS) Guideline 3–2012, Exterior Enclosure Technical Requirements for the Commissioning Process, as they relate to energy, water, indoor environmental quality, and durability.

Commissioning authority must complete the following:

- Review contractor submittals.
- Verify inclusion of systems manual requirements in construction documents.
- Verify inclusion of operator and occupant training requirements in construction documents.
- Verify systems manual updates and delivery.
- Verify operator and occupant training delivery and effectiveness.
- Verify seasonal testing.
- Review building operations 10 months after substantial completion.
- Develop an on-going commissioning plan.

WELL BUILDING

WELL BUILDING

AIR

The WELL Building Standard™ (WELL) establishes requirements in buildings that promote clean air and reduce or minimize the sources of indoor air pollution.

BACKGROUND

Clean air is a critical component to our health. Air pollution is the number one environmental cause of premature mortality, contributing to 50,000 premature deaths annually in the United States and approximately 7 million, or one in eight premature deaths worldwide.

Globally, outdoor air quality is deteriorating due to pollution from traffic, construction, agricultural activity, combustion sources and particulate matter. Because ambient air diffuses easily, even distant sources of pollution have a huge impact on the more than 15,000 liters of air we breathe every day. Indoor air quality can be degraded by these outdoor sources, as well as by off-gassing...read more

FEATURES

Project Types | Pilot Programs

01 Air quality standards

14 Air infiltration management

	Core & Shell	New & Existing Interiors	New & Existing Buildings
1: Air Leakage Testing	O	O	O

WELL BUILDING

14. Air infiltration management

Intent: To minimize air quality and thermal comfort issues resulting from the infiltration of untreated air through the building envelope.

OVERVIEW | AMENDMENTS 0 | EQUIVALENCIES 1 | ALTERNATIVE ADHERENCE PATH 1 | TECHNICAL FAQ 0

Indoor air quality and thermal comfort can be compromised by leaks and gaps that break the building's air barrier. These weak points are not only wasteful but can also lead to conditions conducive to growth of molds and the infiltration of pests or polluted air.

Part 1: Air Leakage Testing

The following is performed after substantial completion and prior to occupancy to ensure the structure is airtight:

a.[1] Envelope commissioning in accordance with ASHRAE Guideline 0-2005 and the National Institute of Building Sciences (NIBS) Guideline 3-2012 (for new construction or structural renovation).

b. Detailed plan for action and remediation of unacceptable conditions.

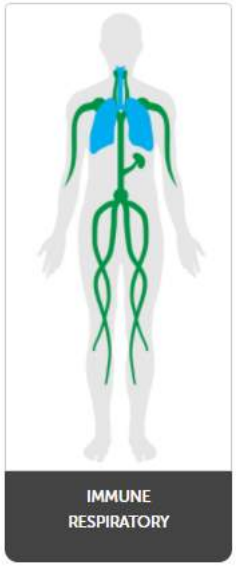
Part 2: Leak Tests for Residences

One of the following methods is used to evaluate the building envelope:

a. Blower door testing.

b. Infrared thermography.

c. Hot-wire anemometer.



IMMUNE
RESPIRATORY

09

BECx TO ACHIEVE PERFORMANCE

Continuous Air Barriers:
When is Code “Good Enough”?

BUILDING ENCLOSURE COMMISSIONING

"If you do the wrong thing right, it's still wrong? Right? This is the basic difference between quality control and quality assurance."

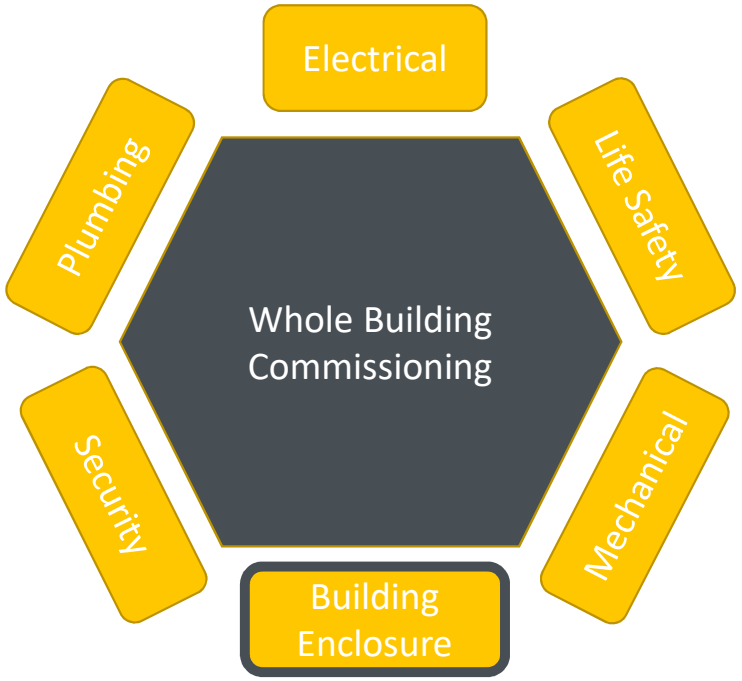
"**Quality Assurance** is figuring out what the right thing to do is."

"**Quality Control** is executing it."

- **Dr. J. Lstiburek. BSI-039: "Five Things"**

https://buildingscience.com/documents/insights/bsi-039-five-things

BUILDING ENCLOSURE COMMISSIONING



BUILDING ENCLOSURE COMMISSIONING

"**Building Enclosure Commissioning (BECx)** is a process that begins with the establishment of the Owner's Project Requirements (OPR) and **endeavors to ensure that the exterior enclosure** and those elements intended to provide environmental separation within a building or structure **meet or exceed the expectations of the Owner**."

- ASTM E2813-2012

BUILDING ENCLOSURE COMMISSIONING

Process

03

WHOLE BUILDING AIRTIGHTNESS TESTING

Air Barrier the Lost Chapter

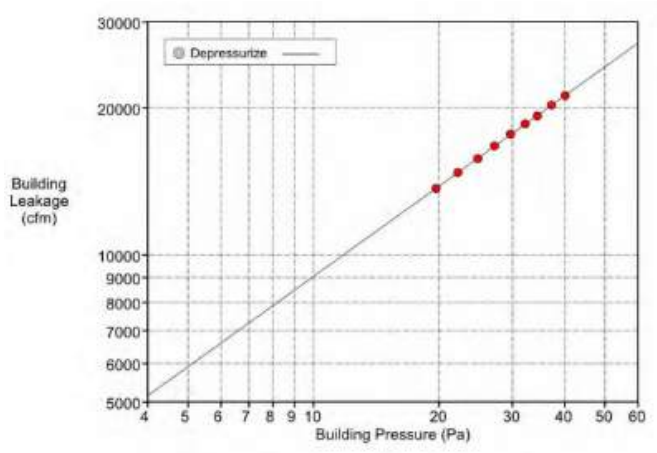
PRODUCT AND SYSTEM PERFORMANCE

➢ Building :

✓ Assembly Based and Quantitative Performance

ASTM E779 " *Standard Test Method for Determining Air Leakage Rate by Fan Pressurization*"

Multipoint Regression Method



Induced Pressure vs. Flow Pressure, Depressurize Set

PRODUCT AND SYSTEM PERFORMANCE

➢ Building :

✓ Assembly Based and Quantitative Performance

ASTM E1827 “ *Standard Test Method for Determining Airtightness of Buildings Using an Orifice Blower Door”*

- Single Point Method
  - Multiple flow measurements near a single pressure
- Two-Point Method
  - Multiple flow measurements near two pressures.

PRODUCT AND SYSTEM PERFORMANCE

➢ Building :

✓ Assembly Based and Quantitative Performance

USACE Air Leakage Test Protocol for Building Envelopes

- Test procedure/building preparation is more clearly defined than ASTM E779
- Requires positive and negative pressurization sets
- Defines acceptable induced pressure range
- Does not allow data extrapolation (10 data points and must measure at 75 Pa)
- Defines acceptable ranges for correlation coefficient squared, r^2, and the pressure exponent, n
- **Requires diagnostic procedures included in ASTM E1186 (Infrared and smoke tracers) to help determine air leakage sites.**

PERFORMANCE STANDARDS

➢ Building :

ABAA *"Standard Method for Building Enclosure Airtightness Compliance Testing"*

- Evolution of ASTM E779 and ASTM E1827 due to shortcomings of the original standards
- Includes multipoint regression, single point, and two point methods.
- Will become a new ASTM standard, phasing out ASTM E779.

04

AIRTIGHTNESS IN ENERGY MODELING

Air Barrier the Lost Chapter

ENERGY MODELING

➢ Infiltration:

Can mainstream energy modelling software (no CFD) adequately represent infiltration ?

- Default ASHRAE weather data (TARP Formulation)
- User input
  - Default values
    - What does *Neutral, Poor Construction* really mean?

ENERGY MODELING

➢ Infiltration – Input:

Understand how your software works

Understand how Infiltration works!

- Most design professionals understand the basic concepts of infiltration, but fail to truly understand how it works in a building

ENERGY MODELING

➢ Infiltration – Input:

Cooling/Heating Leakage rates

- Depending on location/weather data infiltration in summer may reduce cooling load and thus be excluded from analysis

Infiltration schedules

- Only when HVAC System fans Off?
  - Do you have the right system controls to make this a valid option?

ENERGY MODELING

➢ Infiltration – New Buildings:

- Applicable Building Performance Standards
  - 0.4 CFM/SF @75 Pa
- How does this translate to the model?

$$Q=C(dP)^n$$

- What is the normal operating pressure?
  - Is building pressure directly controlled or monitored

ENERGY MODELING

➢ Infiltration – New buildings:

How does modern building design perform?

- Now that infiltration is more readily acknowledged, do we need a round two of the analysis performed by Emmerich/Perisly?

If energy modelling practices are updated to reflect a prescribed leakage rate, how critical is it to validate with performance testing?

05

FUTURE OPPORTUNITIES IN AIRTIGHTNESS

Air Barrier the Lost Chapter

intertek
Total Quality. Assured.

PROVIDER: **INTERTEK**
PROVIDER NUMBER: **404108121**
COURSE NUMBER: **BCLUNA006-01P**

CONTINUOUS AIR BARRIERS: WHEN IS CODE "GOOD ENOUGH"?

Pushing the Enclosure
28 September 2017

TAKE AWAYS

1. **Not all codes handle air barriers similarly**
2. **Whole building air leakage testing gaining more traction**
3. **Materials and Assemblies matter less, though still important**
4. **BECx is a quality assurance program to assist in achieving high performance targets, like air tightness.**
5. **Whole building requirements are getting more stringent**
   - 0.40 cmf/sqft @ 75 Pa to 0.30…0.25…0.10…

THANK YOU!

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