International Roofing Expo

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San Antonio, Texas

Change is in the air:
Air barrier requirements for roof assemblies

presented by

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National Roofing Contractors Association

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Professional Roofing, June 2010

Tech Today

Guidelines for air barriers

Air leakage in mechanically attached single-ply membranes is a concern

by Mark S. Graham

ASHRAE 189.1, "Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings," provides guidelines for the use and design of air barriers in roof assemblies. If you are involved with the design of low-slope roof systems, you should know how air barriers function and how they are designed.

Air barriers

Air barriers are used as building envelope components to minimize the amount of air intrusion and air leakage into and out of buildings and building envelope components.

Air barriers and vapor retarders play similar but not identical roles in buildings. Vapor retarders are intended to restrict the passage of water vapor through materials, and air barriers are intended to restrict the passage of air flow through materials.

ASHRAE 189.1

ASHRAE 189.1 defines "continuous air barrier" as the combination of a building envelope's interconnected materials, assemblies, and flexible sealed joints and components that provide airtightness to a specified permeability.

ASHRAE 189.1's Normative Appendix B—Prescriptive Continuous Air Barrier provides characteristics for continuous air barriers. The standard states they should be continuous, joined and sealed to adjacent assemblies' air barriers, capable of withstanding positive and negative pressures, and be installed according to manufacturer instructions.

Compliance with ASHRAE 189.1's guidelines for opaque building envelopes (roofs) is determined by evaluating specific individual materials, building assembly components or a whole building.

ASTM E2178, "Standard Test Method for Air Permeance of Building Materials," provides a means of testing flexible sheets' and rigid materials' effectiveness as air barriers. ASHRAE 189.1 indicates individual materials' air permeabilities should not exceed 0.004 cfm/ft² under a pressure differential of 0.3 inches of water tested according to ASTM E2178 to qualify as an air retarder.

ASHRAE 189.1 specifically states the following common roofing materials comply with this requirement when all joints are sealed: cast-in-place and precast concrete, minimum ¾-inch-thick plywood or oriented strand board, minimum ½-inch-thick gypsum board, minimum ¾-inch-thick extruded polystyrene insulation, built-up and polymer-modified bitumen roof membranes, and fully adhered single-ply roof membranes.

Building assembly components found to have an average air leakage less than 0.04 cfm/ft² under a pressure differential of 0.3 inches of water tested according to ASTM E2357, "Standard Test Method for Determining Air Leakage of Air Barrier Assemblies," or ASTM E1677, "Standard Specification for Air Barrier (AB) Material or System for Low-Rise Framed Building Walls," can be considered air retarders according to ASHRAE 189.1.

Also, ASHRAE 189.1 indicates whole buildings that demonstrate air leakage rates less than 0.04 cfm/ft² under a pressure differential of 0.3 inches of water tested according to ASTM E779, "Standard Test Method for Determining Air Leakage Rate by Fan Pressurization," can be considered air retarders.

Concerns

Although ASHRAE 189.1 provides guidelines for the design and use of air retarders in buildings and buildings' roof assemblies, it also illustrates mechanically attached single-ply membrane roof systems do not necessarily function as adequate continuous air barriers.

NRCA, the Canadian Roofing Contractors Association and a number of single-ply membrane manufacturers are sponsoring a long-term research project intended to quantify the air-leakage rates of mechanically attached single-ply membrane roof systems. This research is being conducted at the National Research Council Canada in Ottawa, Ontario. Results are expected to be available in 2012.

For more information about air leakage, see "How much air is too much?" January issue, page 26.

Mark S. Graham is NRCA's associate executive director of technical services.

Professional Roofing, July 2012

TECH TODAY

Air barriers and the new energy code

IECC 2012's air barrier requirements could limit design options

by Mark S. Graham

The *International Energy Conservation Code,® 2012 Edition* (IECC 2012) includes a new requirement intended to limit air leakage through buildings' thermal envelopes, including roof assemblies. The requirement, a change from IECC 2009, will significantly affect the design and installation of certain roof assemblies.

IECC 2012

IECC 2012 Section C402.4—Air Leakage (Mandatory) requires all commercial (nonresidential) buildings, except those in climate zones 1 through 3, to include a continuous air barrier. Climate zones 1 through 3 include Alabama, Florida, Hawaii, Louisiana, Mississippi and South Carolina and portions of Arizona, Arkansas, California, Georgia, Nevada, New Mexico, North Carolina, Oklahoma, Tennessee, Texas and Utah.

The required air barrier is permitted to be located on the inside or outside of the building envelope, located within assemblies composing the building envelope and any combination thereof. The air barrier is required to be across all joints and assemblies comprising the building envelope. Air barrier joints and seams need to be sealed, including sealing transitions and changes in materials. Special provisions are provided for sealing recessed lighting fixtures, air barrier penetrations, doors and access openings, and outdoor air intakes and exhausts.

IECC 2012 provides for three compliance options for air barrier selection and evaluation: materials, assemblies or whole building testing. Using IECC 2012's materials option, a material with an air permeability no greater than 0.004 cfm/ft² under a pressure differential of 0.3 inches water gauge tested according to ASTM D2178, "Standard Test Method for Air Permeance of Building Materials," complies. Also, a number of specific materials—including minimum ⅜-inch-thick plywood or oriented strand board; minimum ½-inch-thick extruded polystyrene or foil-faced polyisocyanurate insulation or gypsum or cement board; cast-in-place and precast concrete; and built-up, polymer-modified bitumen and fully adhered single-ply membranes—are deemed to comply provided their joints are sealed and materials are installed as air barriers according to manufacturers' instructions.

ON *the* WEB

To see IECC 2012's climate zone map and obtain IECC 2012, log on to www.professionalroofing.net.

The assemblies option allows assemblies of materials to comply with an average air leakage not to exceed 0.04 cfm/ft² under a pressure differential of 0.3 inches of water gauge when tested according to ASTM E2357, "Standard Test Method for Determining the Air Leakage of Air Barrier Assemblies"; ASTM E1677, "Standard Specification for Air Barrier (AB) Material or System for Low-Rise Framed Building Walls"; or ASTM 283, "Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen."

The whole building option requires complete buildings be tested and the resulting air leakage rate not exceed 0.4 cfm/ft² under a pressure differential of 0.3 inches of water gauge when tested according to ASTM E7979, "Standard Test Method for Determining Air Leakage Rate by Fan Pressurization."

Considerations

Although certain roof system types, including built-up, polymer-modified bitumen and adhered single-ply membranes are considered deemed to comply with the new air barrier requirement, other roof system types will require additional testing to substantiate compliance. These include mechanically attached and ballasted single-ply membranes, metal panels and shingle-type roof coverings.

Did you KNOW ?

More information about roofing-related requirements contained in IECC 2012 is available in *Guidelines for Complying with Energy Code Requirements for Roof Assemblies: International Energy Conservation Code 2009 and 2012 Editions*. To purchase the manual, go to shop.nrca.net.

For some of these roof system types, it may be more practical to provide the necessary air barrier at or below the roof deck level by using a cast-in-place or precast concrete roof deck, spray foam below the roof deck or a gypsum board ceiling. IECC 2012 includes specific density and thickness requirements for closed and open-cell spray foam for it to be considered deemed to comply.

I recommend designers consult roof system manufacturers regarding how their specific roof system configurations function as air barriers according to IECC 2012's requirements. Also, roof system manufacturers should be consulted for specific penetration and perimeter sealing instructions to comply with IECC 2012's requirements.

MARK S. GRAHAM is NRCA's associate executive director of technical services.

Some terms

ASTM E1677

air leakage: the movement/flow of air through the building envelope, which is driven by either positive (infiltration) or negative (exfiltration) pressure difference, or both.

air infiltration: air leakage into the building driven by positive pressure.

Some more terms

ASTM E1677

air barrier: A material or system in building construction that is designed and installed to reduce air leakage either into or through the opaque wall.

vapor retarder: a material or system that adequately impedes the transmission of water vapor under specified conditions.

Still some more terms

air barrier system: a combination of air barrier assemblies installed to provide a continuous barrier to the movement of air through portions of building enclosure assemblies.

continuity: an uninterrupted succession of air barrier materials, accessories and assemblies.

Still another term

ASTM E2357

air barrier accessory: a transitional component of the air barrier that provides continuity.

One last term

ASTM E2357

air leakage rate: the quantitative measure of air passage through a set surface area of an assembly within a given time period under a pressure differential between the two sides of the assembly.

Codes and standards

International Energy Conservation Code, 2012 Edition (Climate Zones 4-8)

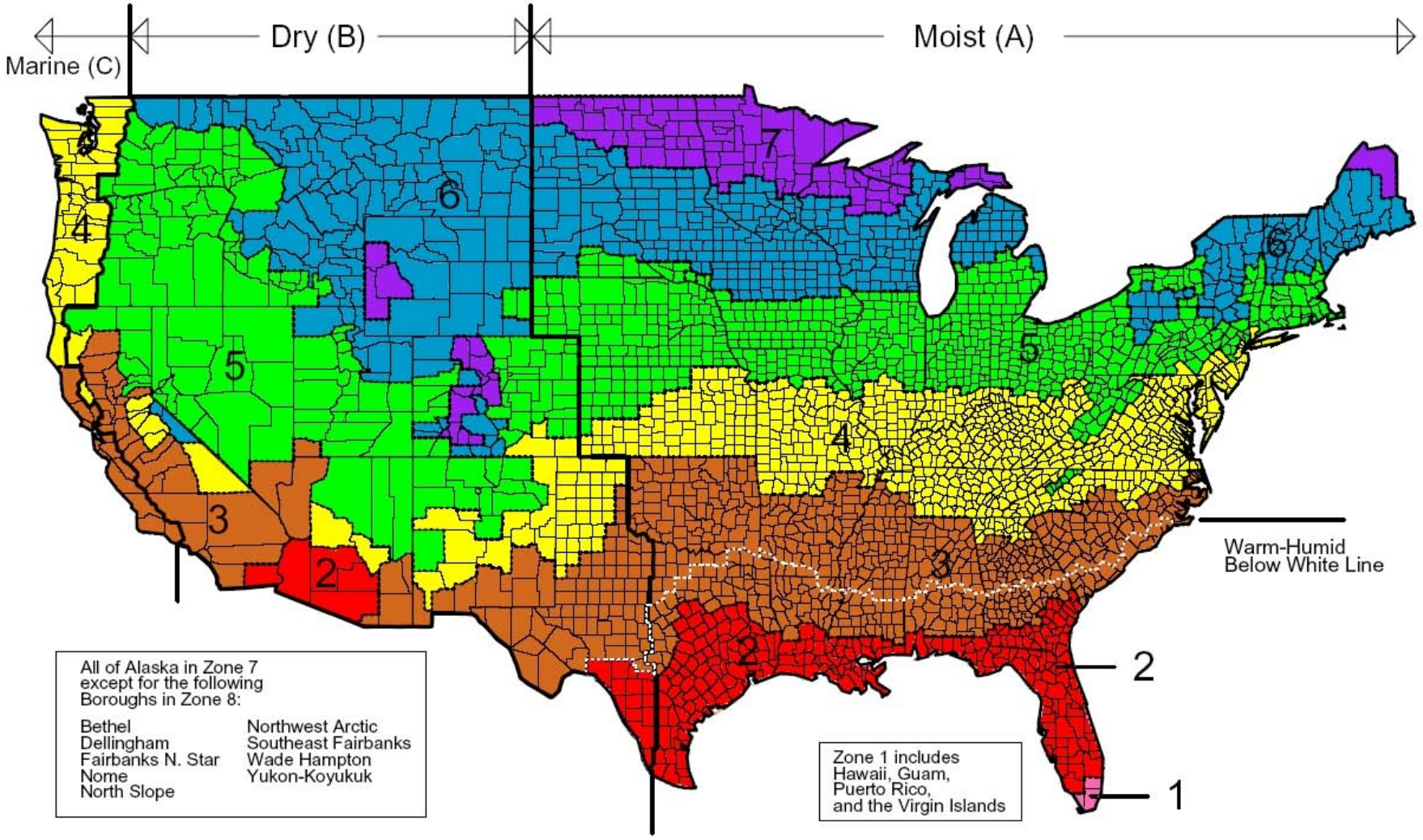
- ASHRAE 90.1-10 alternative (All Climate Zones)

International Green Construction Code, 2012 Edition (All Climate Zones)

- ASHRAE 189.1-09 alternative (All Climate Zones)

Climate zones

IECC 2012, Section C301—Climate Zones



IECC 2012

Sec. C402.2-Air leakage (Mandatory)

- Materials:
  - 0.004 cfm/ft^2 (0.02 L/s·m^2) at 0.3 inches water gauge (75 Pa) using ASTM E2178
  - Deemed to comply options
- Assemblies:
  - 0.04 cfm/ft^2 (0.2 L/s·m^2) at 0.3 inches water gauge (75 Pa) using ASTM E2357, ASTM E1677 or ASTM E283
- Whole buildings:
  - 0.40 cfm/ft^2 (2.0 L/s·m^2) at 0.3 inches water gauge (75 Pa) using ASTM E779

IECC 2012

Sec. C402.4.1.2.1-Materials

Deemed to comply options (roofing specific):

- SPF (closed cell), min. 1.5 pcf, min. 1½-inches thick
- Built up roof membrane
- Modified bituminous roof membrane
- Fully adhered single-ply roof membrane

Roof systems requiring testing

- Mechanically-attached single-ply membranes
- Ballasted single-ply membranes
- Metal panels
- Steep-slope:
  - Asphalt shingles
  - Tile
  - Slate
  - Wood

IECC 2012

Sec. C402.4.1-Air Barriers

"A continuous air barrier shall be provided throughout the building thermal envelope…"

"…permitted to be located on the inside or outside of the building envelope, located within the assemblies composing the envelope, or any combination thereof…"

IECC 2012

Sec. C402.4.1-Air Barriers

"…Air barrier joints and seams shall be sealed, including sealing transitions in places and changes in materials…"

"…shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair it ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation…"

IECC 2012

Sec. C402.4.1.1-Air Barrier Construction

"…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 it ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation…"

IECC 2012

Sec. C402.4.2-Air Barrier Penetrations

"…Penetrations…shall be caulked, gasketed or otherwise sealed in a manner compatible with construction materials and location…"

"…shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair it ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation…"

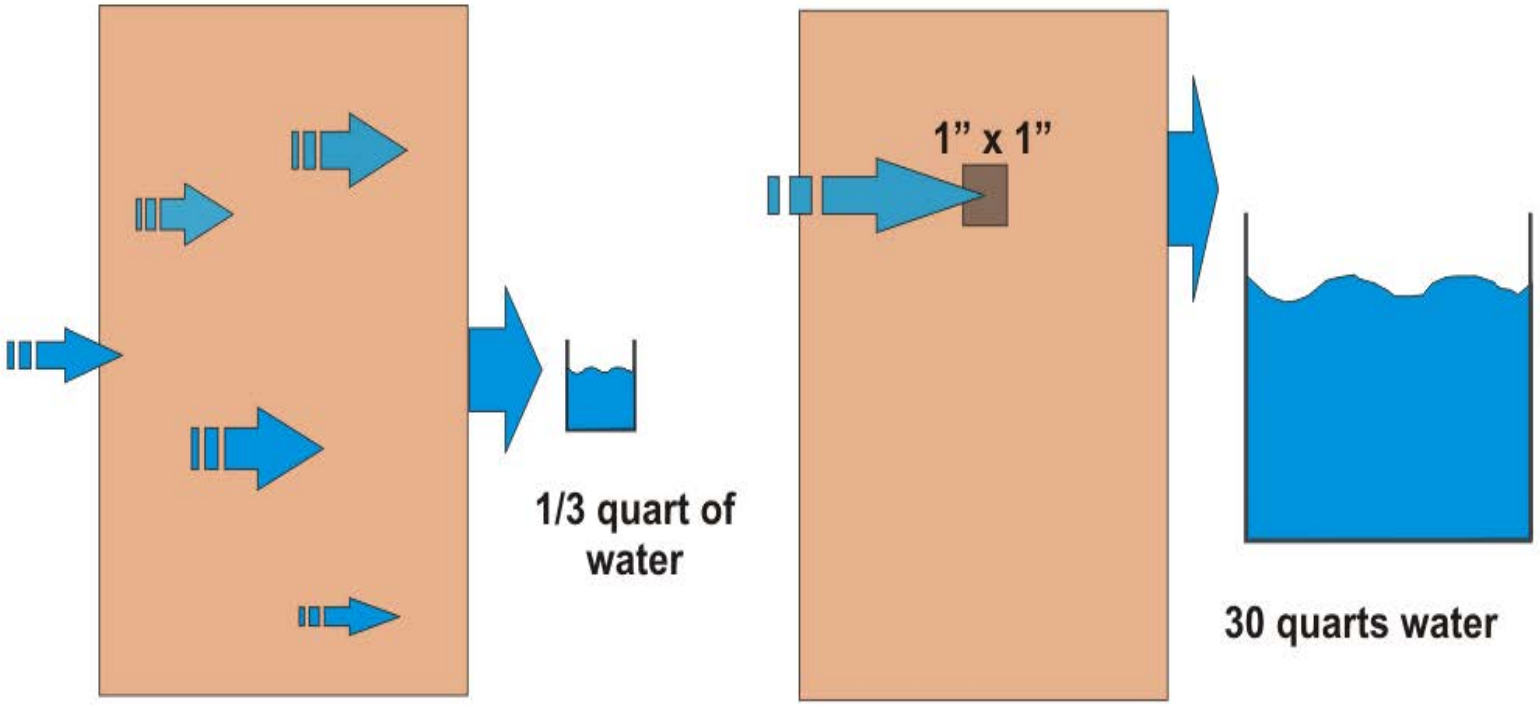
Survey of roof system manufacturers

Change is in the air:
Air barrier requirements for roof assemblies

The Canadian experiece

Controlling air leakage

Air Leakage vs. Diffusion moisture transmission



Int. Temp: 70°F, RH 40%

In most cold climates over an entire heating season, 1/3 quart of water can be collected by diffusion, 30 quarts of water can be collected by air leakage

National Building Code of Canada-2010

Section 5.4. Air Leakage

5.4.1. Air Barrier Systems

5.4.1.1. Required Resistance to Air Leakage

(See Appendix A.)

1) Where a *building* component or assembly separates interior *conditioned* space from exterior space, interior space from the ground, or environmentally dissimilar interior spaces, the properties and position of the materials and components in those components or assemblies shall be such that they control air leakage …

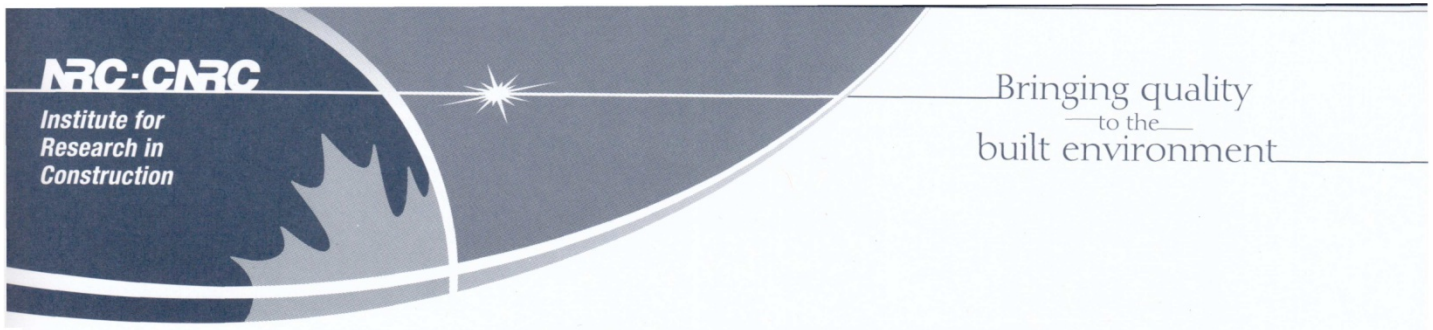
c) minimize the accumulation of condensation in and the penetration of precipitation into the *building* component or assembly…

2) Except as provided in Sentence (3), an *air barrier system* shall be installed to provide the principal resistance to air leakage.

Canadian standards for air barriers

- Proposed CAN/ULC Standard for Air Barrier Materials and Assemblies.
- Canadian Construction Materials Centre Technical Guide for *Air Barrier Systems for Exterior Walls of Low-Rise Buildings.*
- Would require extensive and costly testing to determine air barrier properties of membrane roofing systems.
- Industry maintained low slope membrane roof systems are effective air barriers.

Air leakage and low slope roof membrane assemblies



Air Tightness Characterization of Low Slope Membrane Roof Assemblies

Client Report: B1453.1

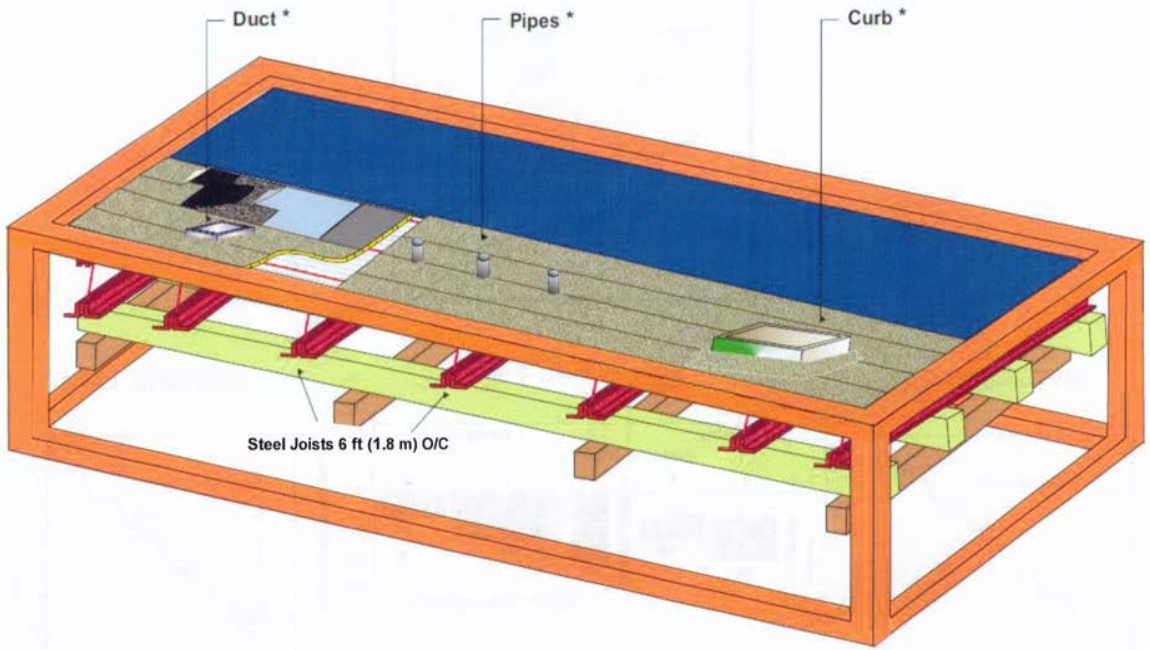
Prepared for

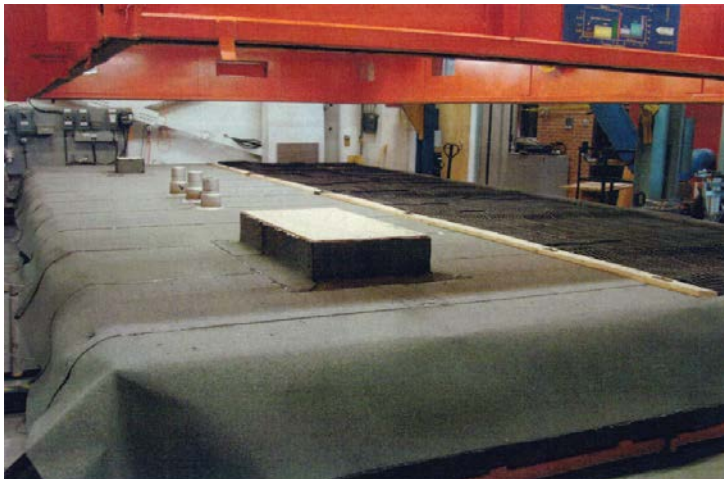
Canadian Roofing Contractor's Association (CRCA)
2430 Don Reid Drive, Suite 100
Ottawa, ON
K1H 1E1 Canada

November 1st, 2010

Air leakage testing

Figure 1: General layout and arrangement of the test specimen at the Dynamic Roofing Facility





Air leakage testing

Figure 5: Methodology for Determining the Air Tightness Rate

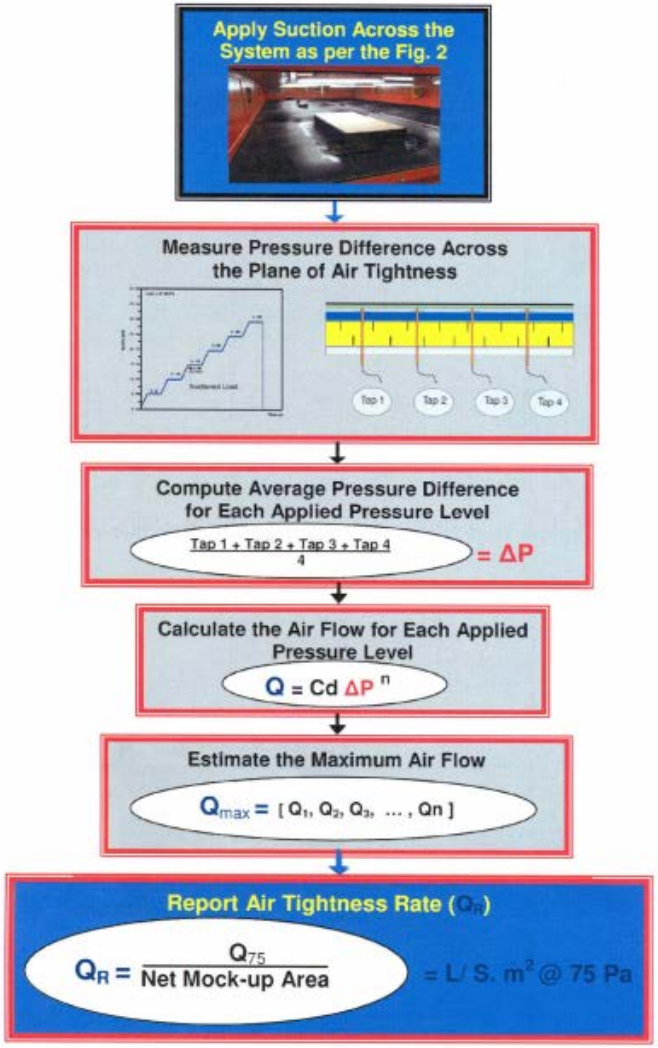
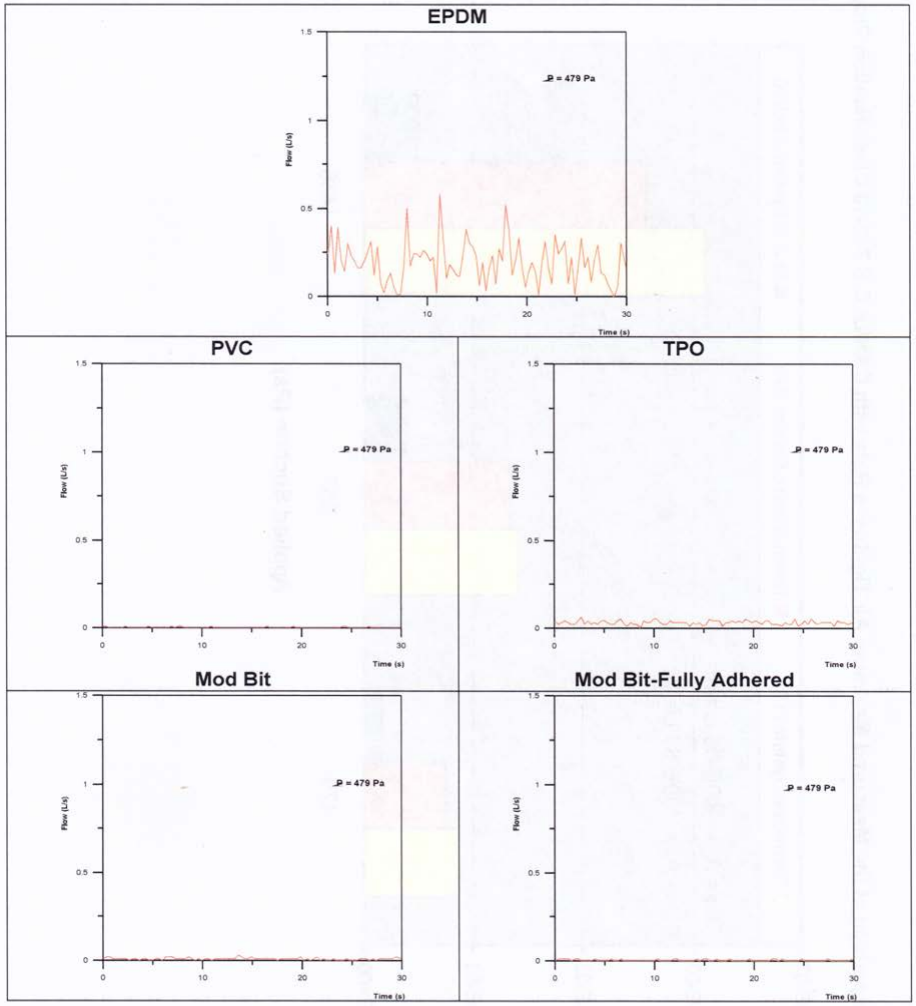


Figure 8: Typical Calculated Air Tightness for Different LSMRA



Note:

- *1 psf = 47.88 Pa and 1 L/s = 2.64E-1 Ga/s*
- *Flow coefficient (Cd) of 2.59E-2 and flow exponent (n) of 0.8 are used for the calculation*

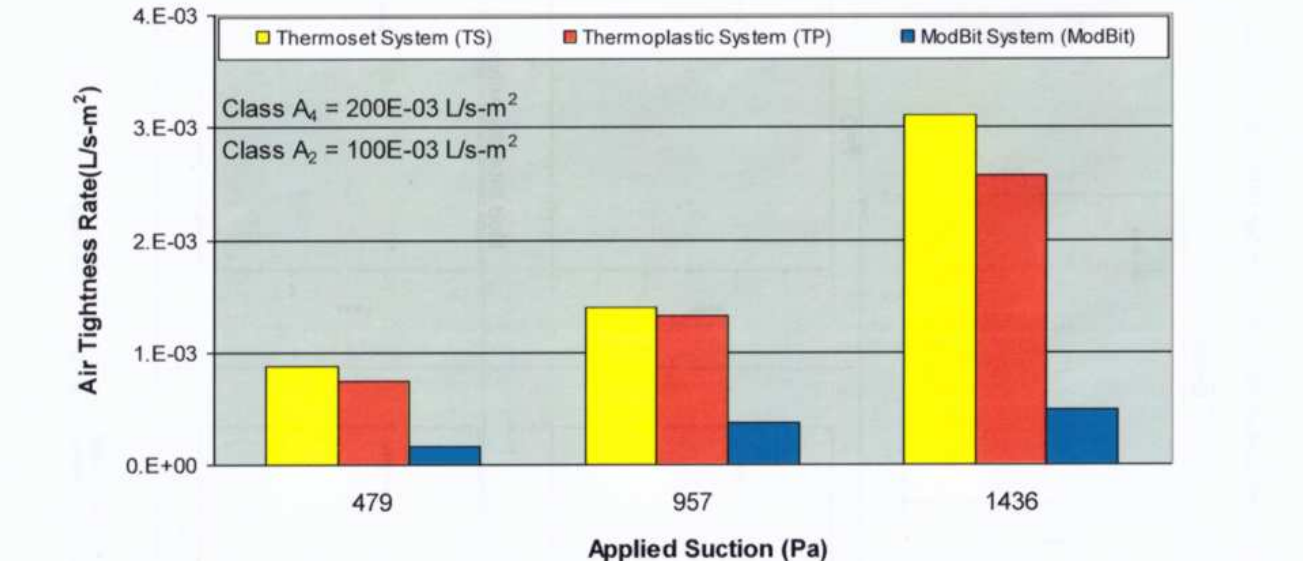
Canadian standards for air barriers

- CAN/ULC-S741, *Standard For Air Barrier Materials – Specification*
  - Air permeance ≤ 0.02 L/(s·m²) at Δ 75 Pa
- CAN/ULC-S742, *Standard for Air Barrier Assemblies – Specification*
  - A1 ≤ 0.05 L/(s·m^2) at Δ 75 Pa
  - A2 ≤ 0.10 L/(s·m^2) at Δ 75 Pa
  - A3 ≤ 0.15 L/(s·m^2) at Δ 75 Pa
  - A4 ≤ 0.2 L/(s·m^2) at Δ 75 Pa
  - A5 ≤ 0.5 L/(s·m^2) at Δ 75 Pa

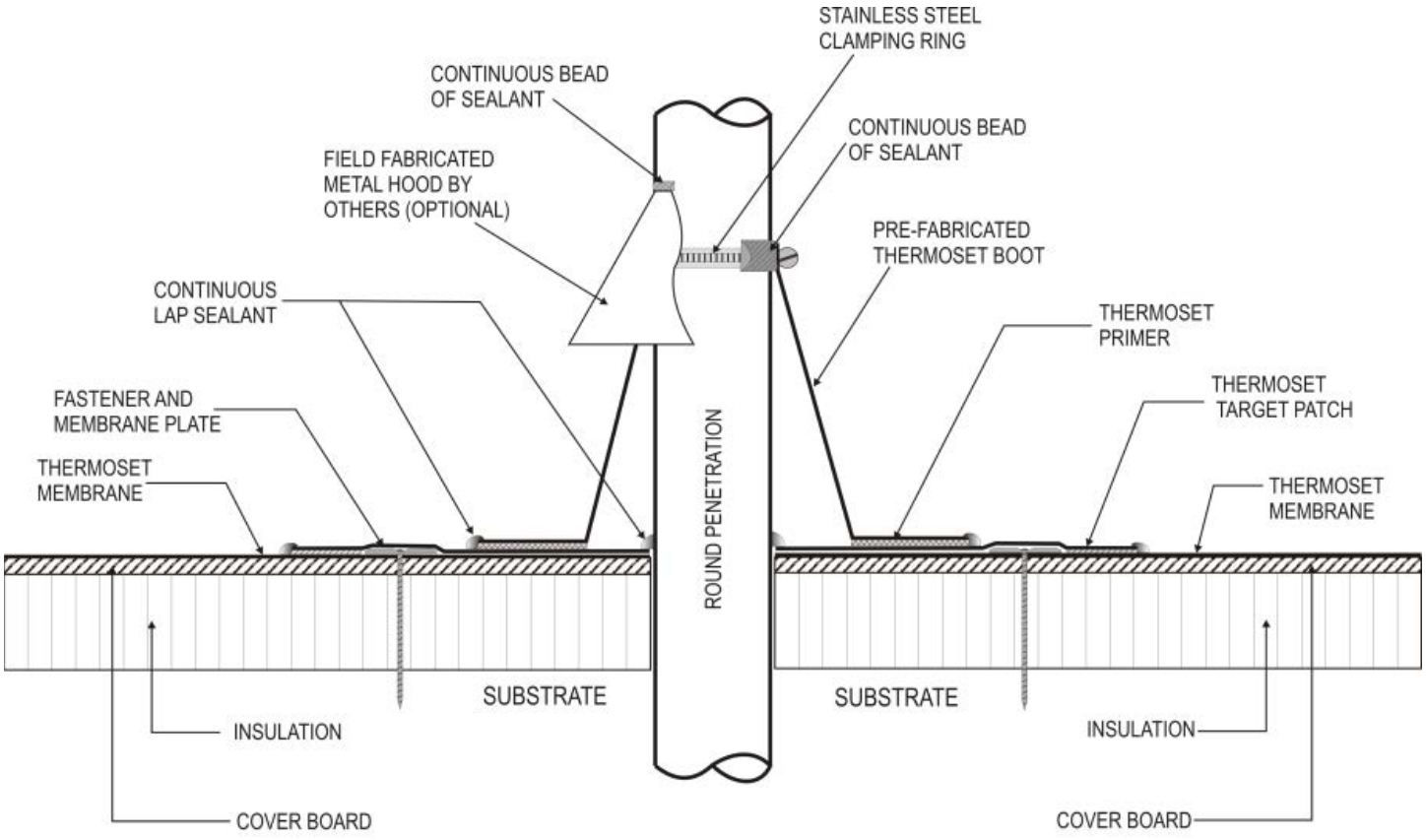
CAN/ULC-S742, *Standard for Air Barrier Assemblies - Specification*

Where the air barrier is a low sloped roof membrane assembly, it is deemed to have an air leakage rate not exceeding 0.20 L/(s•m²) – A4 when constructed in accordance with typical details contained in Annex

Figure 9: Comparison of the Measured Maximum Air Tightness Rate with CAN/ULC S 742-10 Classification Proposal

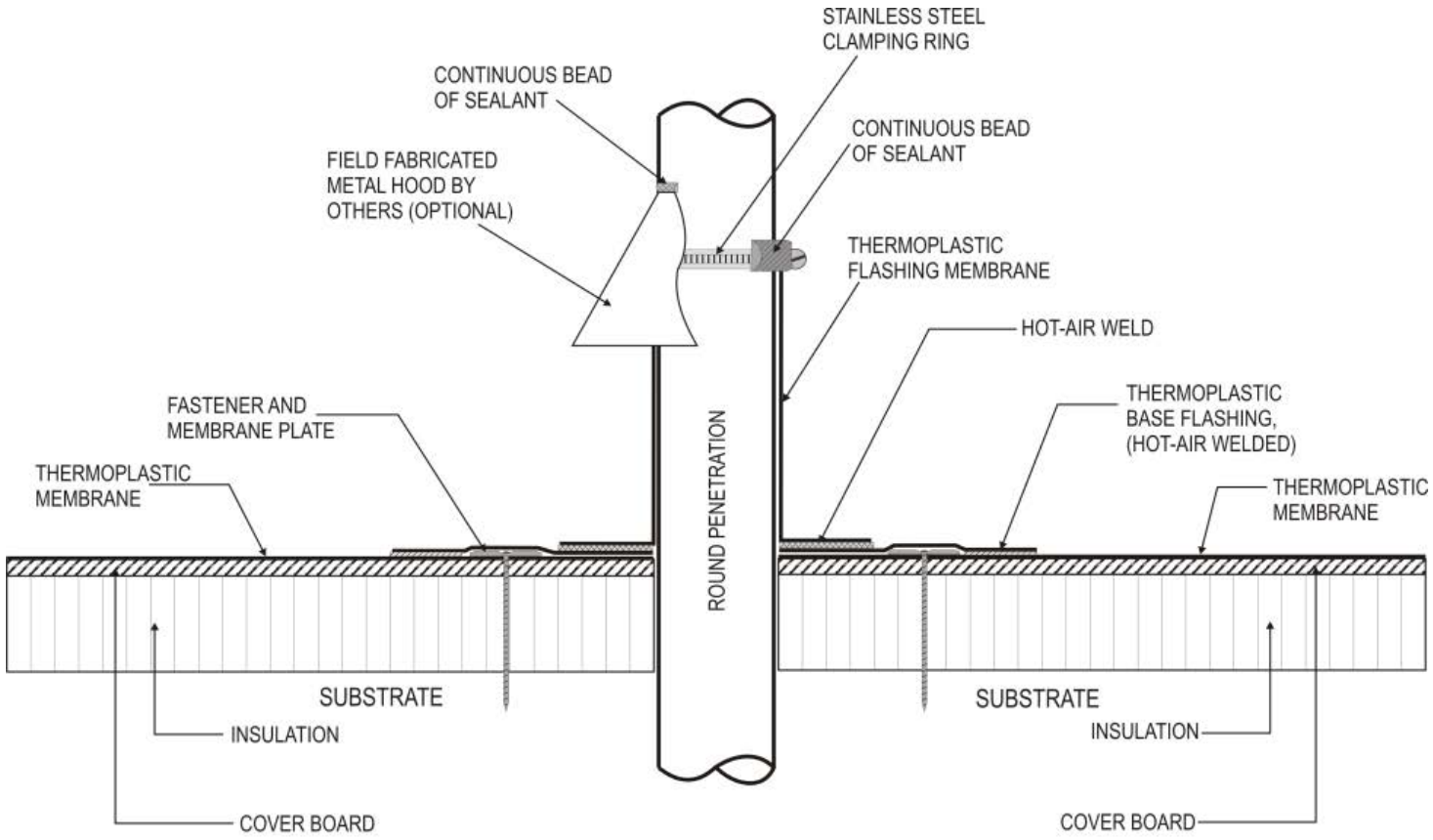


CAN/ULC-S742, *Standard for Air Barrier Assemblies - Specification*



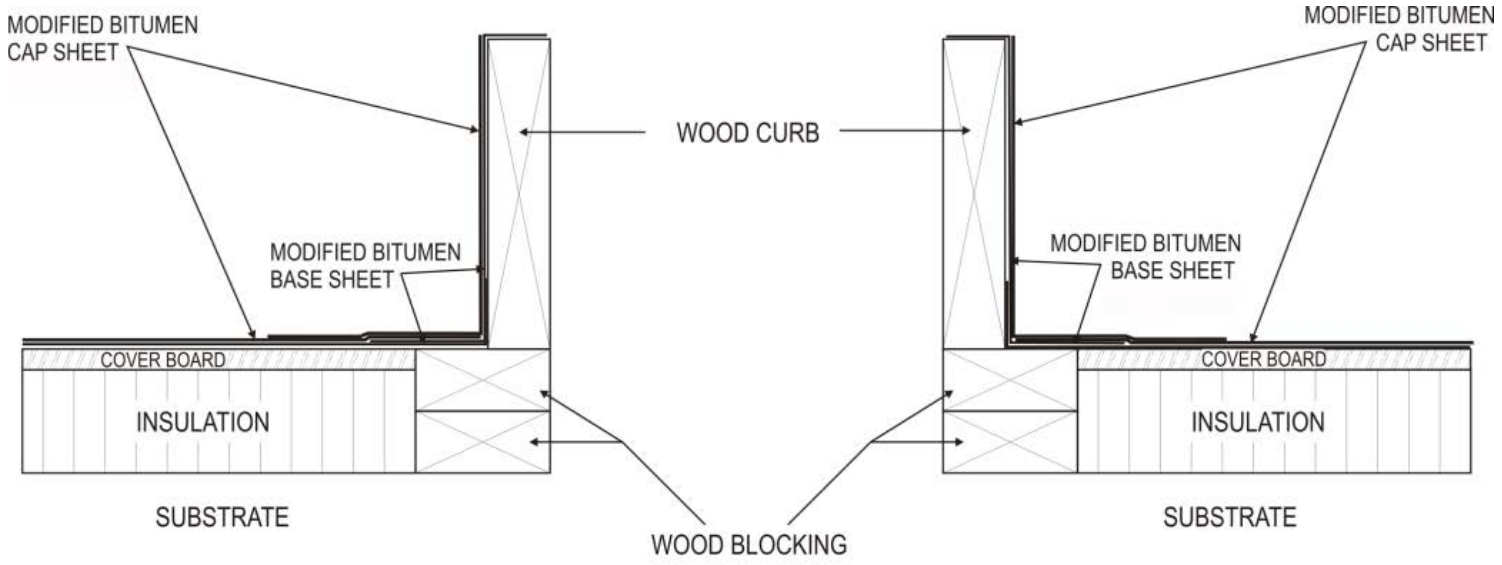
TYPICAL PRE-FABRICATED PIPE BOOT FOR THERMOSET MEMBRANES

CAN/ULC-S742, *Standard for Air Barrier Assemblies - Specification*



TYPICAL FIELD FABRICATED PIPE FLASHING FOR THERMOPLASTIC MEMBRANES

CAN/ULC-S742, *Standard for Air Barrier Assemblies - Specification*



TYPICAL WOODEN CURB FOR MODIFIED BITUMEN MEMBRANES

Location of air barrier in roofs

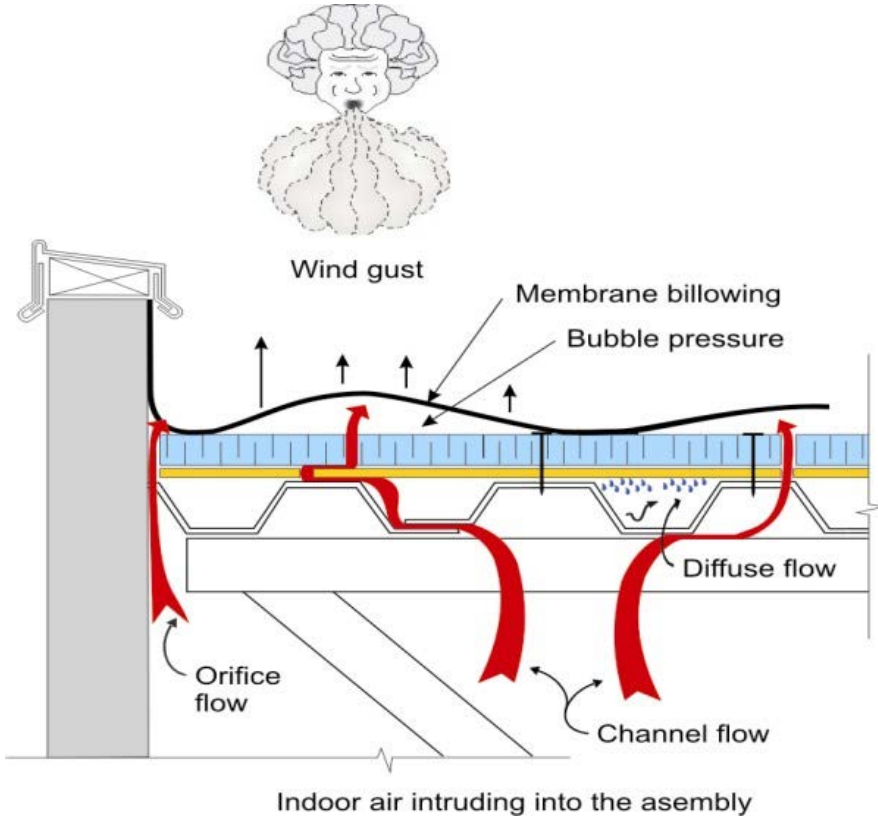
- NBCC – position minimizes the accumulation of condensation.
- Unlike vapor barriers, location of air barrier is not critical and not governed by climatic conditions.
- Important considerations: attachment, ability to resist peak pressures, subsequent tearing and dislocation.

Roof as air barrier

- In mechanically fastened (MF) assemblies wind, mechanical pressure or stack effect may cause flutter and pumping of air into the assembly
- Occurs when there is no or an ineffective vapor retarder
- Can lead to condensation at underside of membrane
- Function of membrane properties (extensibility), fastener spacing and pressure differential

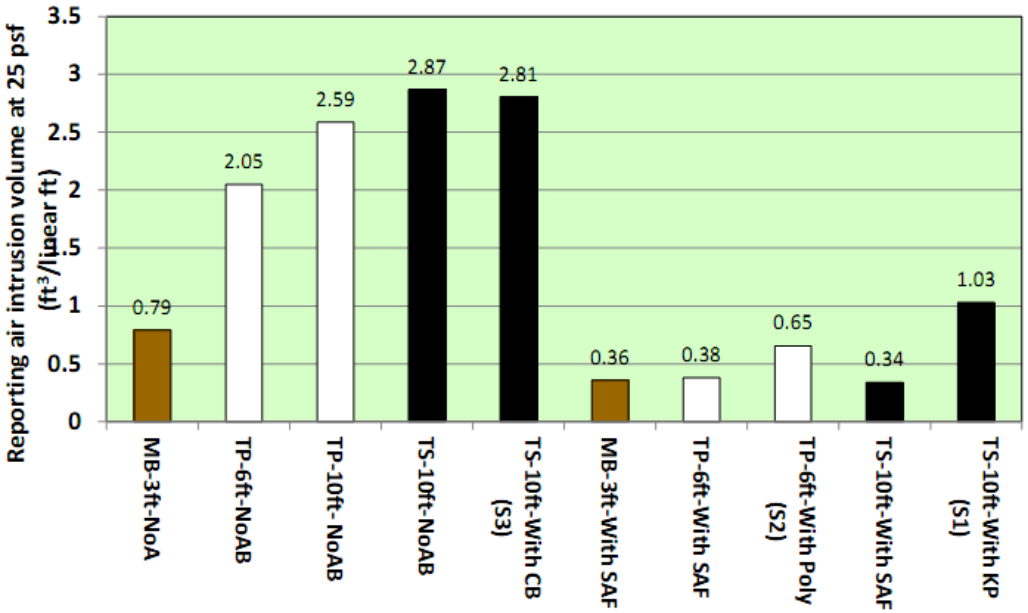
Air intrusion testing

Problem of air intrusion not leakage through the envelope



Air intrusion testing

SIGDERS - Phase V



Reporting air intrusion volume in accordance with ASTM D7586-11

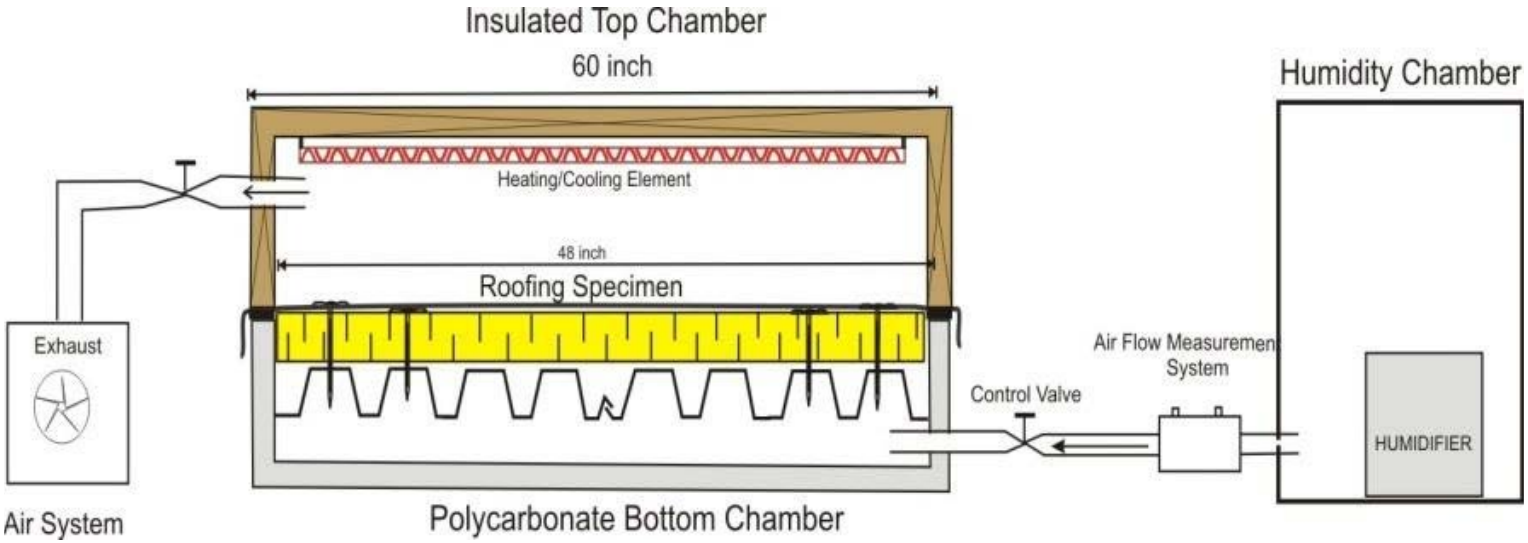
Air intrusion testing

Air intrusion testing

- Small scale study with thermoset system
- With and without air retarder
- With and without differential pressure gradient (suction pressure)

FIGURE 21: TYPICAL SPECIMEN CONSTRUCTION WITH AIR RETARDER FOR MOSITURE STUDY

Air intrusion testing



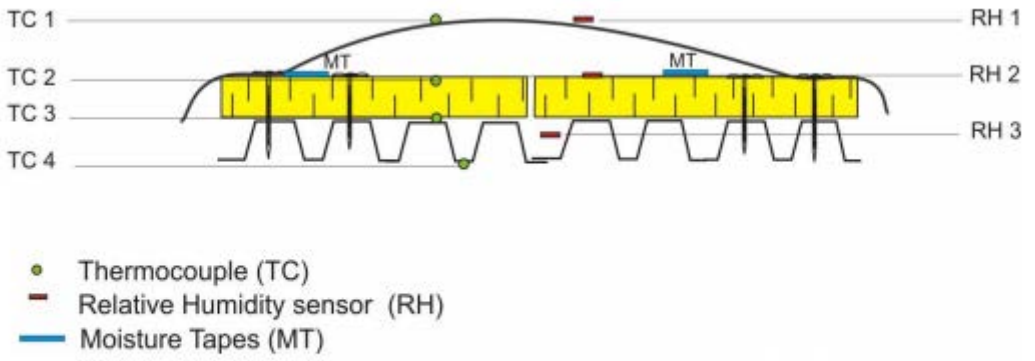


FIGURE 22: INSTRUMENTION FOR TEMPEARTURE AND RH MONITORING

Air intrusion testing

- Without air/vapor retarder air intrusion is a significant driving force in transporting moisture into the system
- Air/vapor retarder at the deck level minimized the moisture loads in the roof system both due to vapor transmission and air intrusion
- Proper installation of air/vapor retarder is vital in the installation of mechanically attached roofing systems

Air intrusion testing

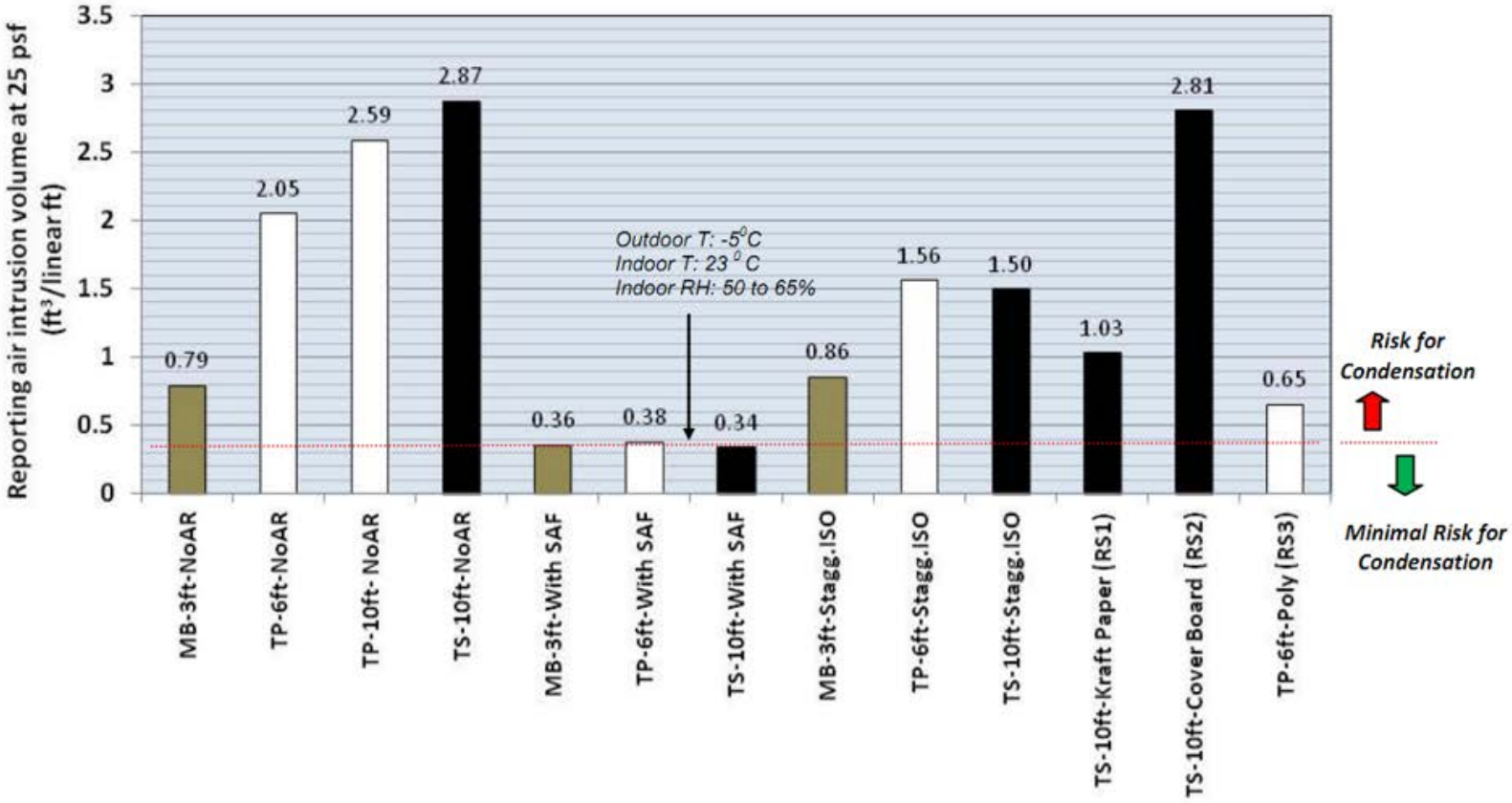


FIGURE 29: AIR INTRUSION LIMIT FOR POTENTIAL CONDENSTAION IN THE ROOFING SYSTEM

Roof as air barrier

Most roofing membranes, although located on the cold side of the insulation, will perform as effective air barriers provided that:

- All penetration and openings are sealed and made airtight.
- Continuity is provided by tying in the roof membrane to the other (wall) air barrier elements.
- vapor retarders, installed in mechanically fastened flexible membrane systems can limit vapor diffusion, air intrusion and membrane deflection.

Conclusions

- New air barrier requirements applicable to "commercial" buildings
- Compliance may be a challenge
- Compliance may dictate roof system choices and detailing
- How will compliance be documented?
- Additional research and information is needed

Interim recommendations

- Verify if IECC 2012 (or other requirements) is applicable
- The deemed to comply options provide some guidance for roof system selection.
- Details (transitions, joints, penetrations) are critical to performance
- Request for information
- Work closely with manufacturers
- Work closely with building officials

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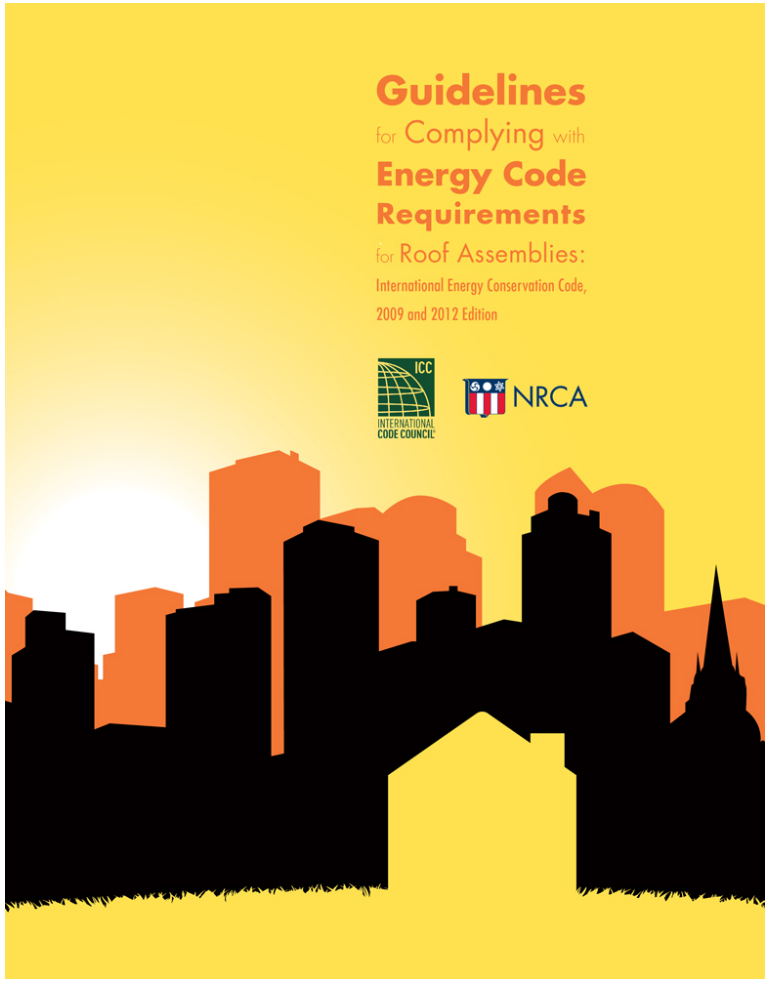
MARK S. GRAHAM is NRCA's associate executive director of technical services.

Energy Codes Manual



- Based upon IECC 2012 with ASHRAE 90.1-07 option and IECC 2012 with ASHRAE 90.1-10 option
- Includes roofing-related code text and NRCA commentary on each section
- Appendix has county-specific prescriptive R-value tables
- Co-branded with ICC; NRCA promotes to industry and ICC promotes to code officials

Questions?

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