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Clearing the Air on Air Barriers

A Guide to Air Barriers in Commercial Low-slope Roof Assemblies

Prepared by GAF Technical Services

April 2018

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Introduction

About GAF

Founded in 1886, GAF is the largest roofing manufacturer in North America.

As the industry leader, GAF proudly offers a comprehensive portfolio of award-winning, innovative roofing products for both steep-slope and commercial properties. Supported by an extensive national network of factory-certified contractors, GAF has built its reputation – and its success – on its steadfast commitment to Advanced Quality, Industry Expertise, and Solutions Made Simple.

GAF offers all major low-slope roofing technologies, including repair and maintenance products and roof restoration systems, as well as new roofing systems (BUR, modified bitumen, TPO, PVC, and liquid-applied roofing). GAF has developed single-ply, asphaltic and liquid-applied membranes with excellent durability to meet the most rigorous industry standards.

For more information, visit <http://www.gaf.com>.

About Air Barriers

Air leakage in buildings has been a concern in the construction industry for many years. Air leakage can affect indoor air quality, energy efficiency, occupant comfort and can contribute to moisture and condensation damage of the building envelope. To address air leakage, model energy codes added air barrier-related provisions. Air barriers were first introduced in the 2012 edition of The International Energy Conservation Code (IECC).

Even though air barriers have been in use for many years, their use persists as one of the most misunderstood concepts in the construction industry. Building material manufacturers, those in the wall and roofing industries, and the building design community do not have a good understanding of the purpose of air barriers and how to design and install an effective air barrier system.

Important Considerations

This guide addresses energy code requirements for air barriers. Therefore, the terms used in this guide are taken directly from the energy codes.

A membrane roof system commonly serves as part of an air barrier system for a building. Membrane roof systems are more commonly installed on commercial buildings. Accordingly, this guide only discusses membrane roof systems used as air barriers to comply with commercial energy code requirements.

The purpose of this guide is to provide some fundamental information on air barriers, code requirements, and recommendations on addressing air barriers in low-slope roof assemblies.

GAF manufactures and sells roofing materials and does not practice architecture or engineering. The design responsibility remains with the architect, engineer, contractor or owner, and the figures illustrated and described herein are furnished solely for guidance purposes. These guidelines are not intended to be all-inclusive. Please consult your design professional for more information.

Air Barrier Basics

The primary function of an air barrier is to prevent or restrict air leakage through a building's envelope. Air barriers are intended to control air flow from the exterior to the interior of a building, as well as from the interior to the exterior of a building.

An air barrier needs to be installed continuously on all sides of a building, i.e., an air barrier should “wrap” the entire building thermal envelope, see Figure 1. In order for an air barrier to function properly, it should:

- Meet permeability requirements;
- Be continuous when installed;
- Accommodate dimensional changes; and
- Be strong enough to support the stresses applied to it.

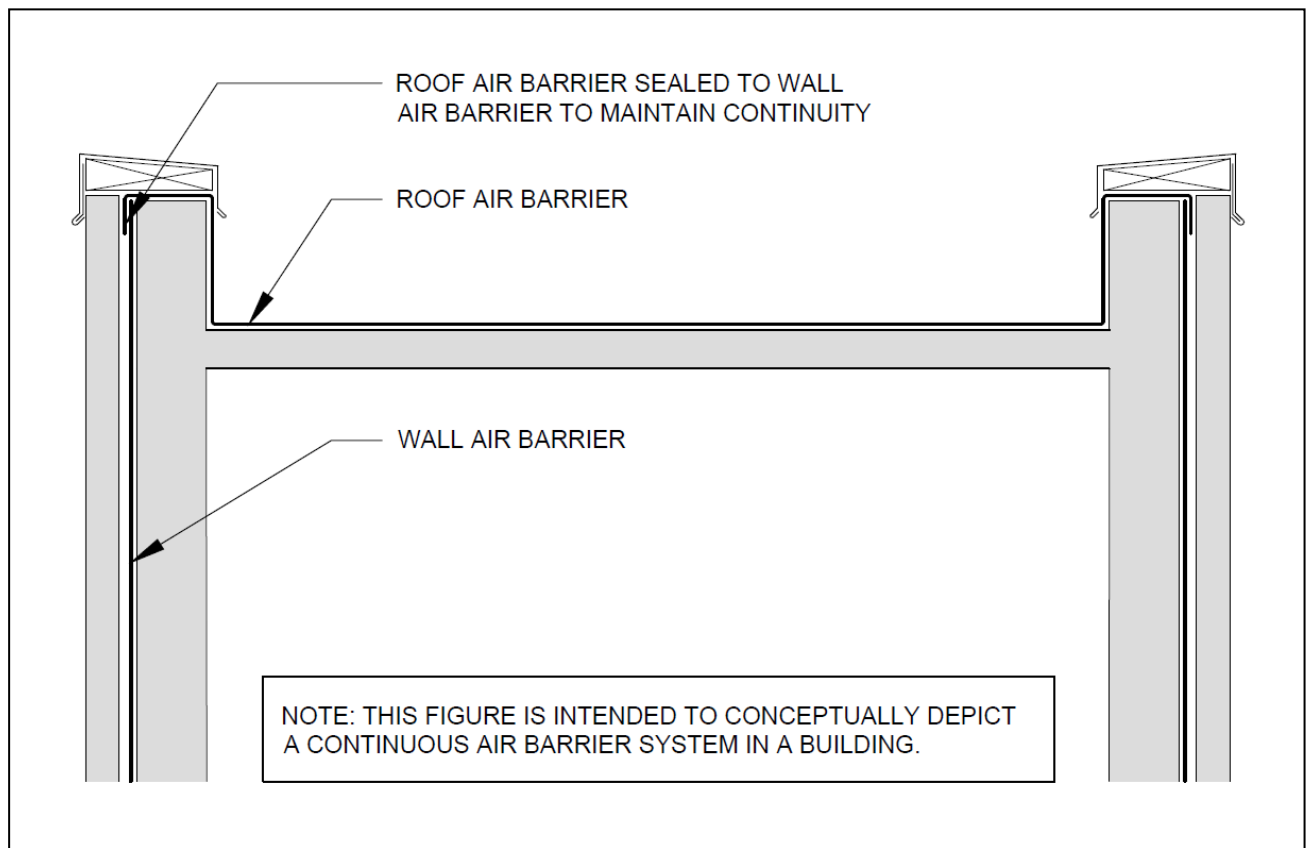


Figure 1: Example of a continuous air barrier in a building envelope

An air barrier is a combination of materials

An air barrier is not a single product or material. Rather, it is a combination of materials assembled and joined together as a system, to provide a continuous barrier to air leakage through the building envelope. An air barrier's effectiveness can be greatly reduced by openings and penetrations, even small ones. These openings can be caused by poor design, poor workmanship, damage by other trades, improper sealing and flashing, mechanical forces, aging and other forms of degradation.

The National Research Council Canada collected research data that illustrated how even small openings can affect overall air leakage performance. For example, only about 1/3 of a quart of water will diffuse through a continuous 4 ft. by 8 ft. sheet of gypsum during a one-month period even though gypsum board has a very high permeance.

However, if there is a 1-square-inch hole in this same sheet of gypsum, about 30 quarts of water can pass through the opening as a result of air leakage. This relationship is illustrated in Figure 2. This example illustrates that air leakage can cause more moisture-related problems than vapor diffusion.

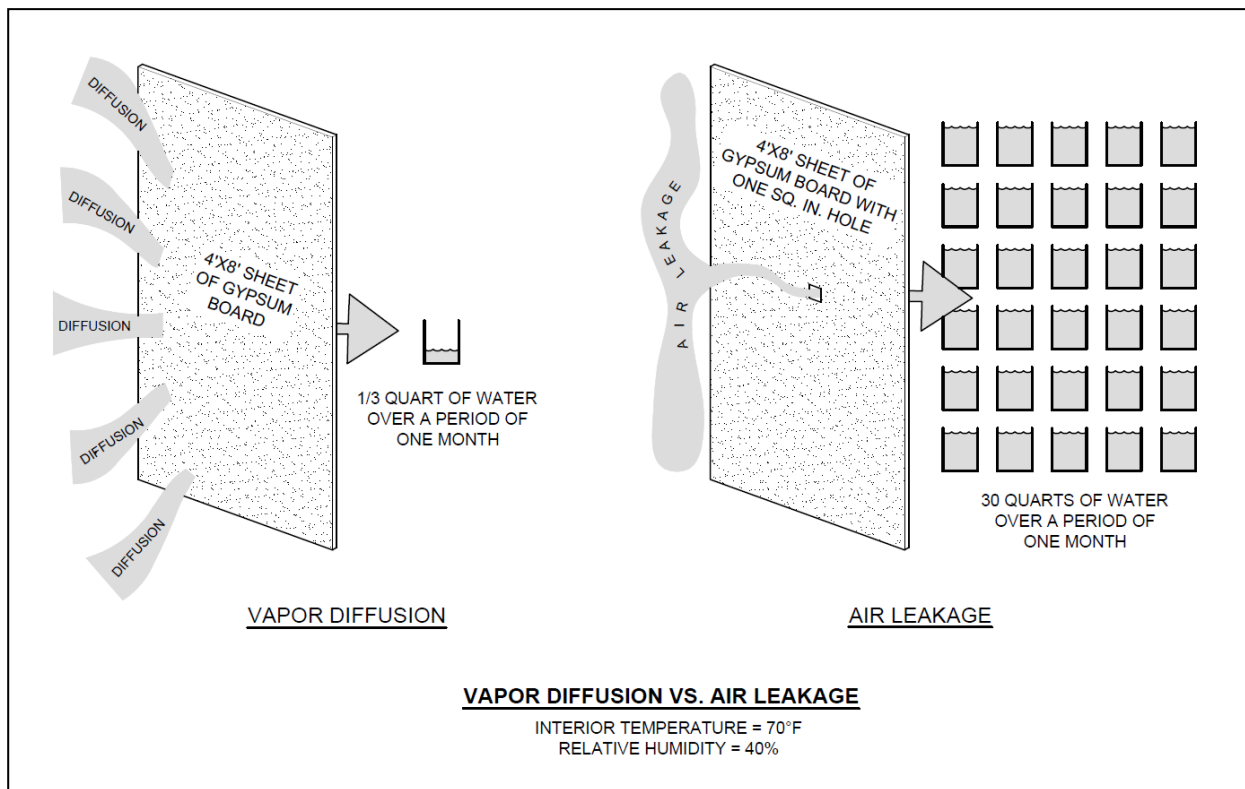


Figure 2: Air leakage vs. vapor diffusion
(Source: Building Science Corporation)

Air Barrier vs. Vapor Retarder

There is often confusion between air barriers and vapors retarders. The purpose of a vapor retarder is to minimize or reduce water vapor diffusion into a low-slope roof system or wall system. In other words, it is used to prevent the formation of condensation in a low-slope roof system or wall system.

Below are some noteworthy considerations on vapor retarders:

- A vapor retarder is often called a vapor barrier; however, building codes refer to it as a vapor retarder.
- A vapor retarder in a roof assembly is not required by building code.
- Generally speaking, a vapor retarder is used where a building's interior humidity conditions are expected to be relatively high, and/or the building is located in a very cold climate.
- A vapor retarder is typically installed on the warm (interior) side of a roof or wall. In a roof assembly, the vapor retarder is normally installed under the primary roof insulation. Therefore, you will often see it installed directly on a roof deck (such as a concrete or wood deck) or on a continuous substrate (such as gypsum board or wood panels) that is installed directly over a metal deck.
- In certain warm, high humidity geographic locations (e.g., the Gulf Coast area), vapor retarders are installed on or near the warm exterior side of roofs and walls of air conditioned buildings.
- There are some materials that serve as a combination vapor retarder and air barrier.

For additional information and GAF guidelines on vapor retarders, refer to the following GAF technical manuals:

- EverGuard® TPO/PVC Adhered Roofing System Overview & General Requirements Manual
- EverGuard® TPO/PVC Ballasted Roofing System Overview & General Requirements Manual
- EverGuard® TPO/PVC Mechanically Attached Roofing System Overview & General Requirements Manual
- EverGuard® Freedom™ TPO Self-Adhered Roofing System Overview & General Requirements Manual
- Drill-Tec™ RhinoBond® Attachment System Overview & General Requirements Manual
- GAFGLAS® Built-Up Roofing Systems Application Specifications Manual
- RUBEROID® APP Torch-Applied Systems Application and Specification Manual
- RUBEROID® SBS Cold-Adhesive Applied Systems Application and Specifications Manual
- RUBEROID® SBS Hot-Mopped Systems Application and Specification Manual
- RUBEROID® SBS Heat-Weld Systems Application and Specification Manual
- Liberty™ SBS Self-Adhered Application and Specification Manual
- Liberty™ SBS Self-Adhered Roofing Systems Application Specifications Manual

Code Requirements

Air barrier requirements are addressed in the International Energy Conservation Code (IECC). IECC is a model code used as the basis of energy codes in most U.S. jurisdictions. Air barriers were first introduced in the 2012 edition of IECC. Many areas have adopted (or are about to adopt) the 2012 or 2015 editions of IECC, so this guide contains the provisions for these two editions.

IECC has air barrier requirements for both residential and commercial buildings. Membrane roof systems commonly serve as an air barrier. Since membrane roof systems are more often installed on commercial buildings, this guide only contains information applicable to buildings defined as commercial by the IECC.

Additionally, IECC allows the use of ANSI/ASHRAE/IES Standard 90.1, “Energy Standard for Buildings Except Low-Rise Residential Buildings” (ASHRAE 90.1) as an alternate method to comply with the energy code. This standard is on a different development cycle than IECC. As a result, IECC 2012 references ASHRAE 90.1-2010 and IECC 2015 references ASHRAE 90.1-2013. The air barrier provisions are practically identical in the 2010 and 2013 editions, so this guide contains the provisions from the 2013 edition.

Important note: *Verify with the building code official where the building is located to determine which code has been adopted. Also keep in mind that state and local jurisdictions may add or delete portions of the model code or have local amendments.*

Paths to Compliance

For new construction, there are multiple compliance paths that can be used to meet air barrier requirements. The paths are shown in flowcharts in Figures 3 and 4.

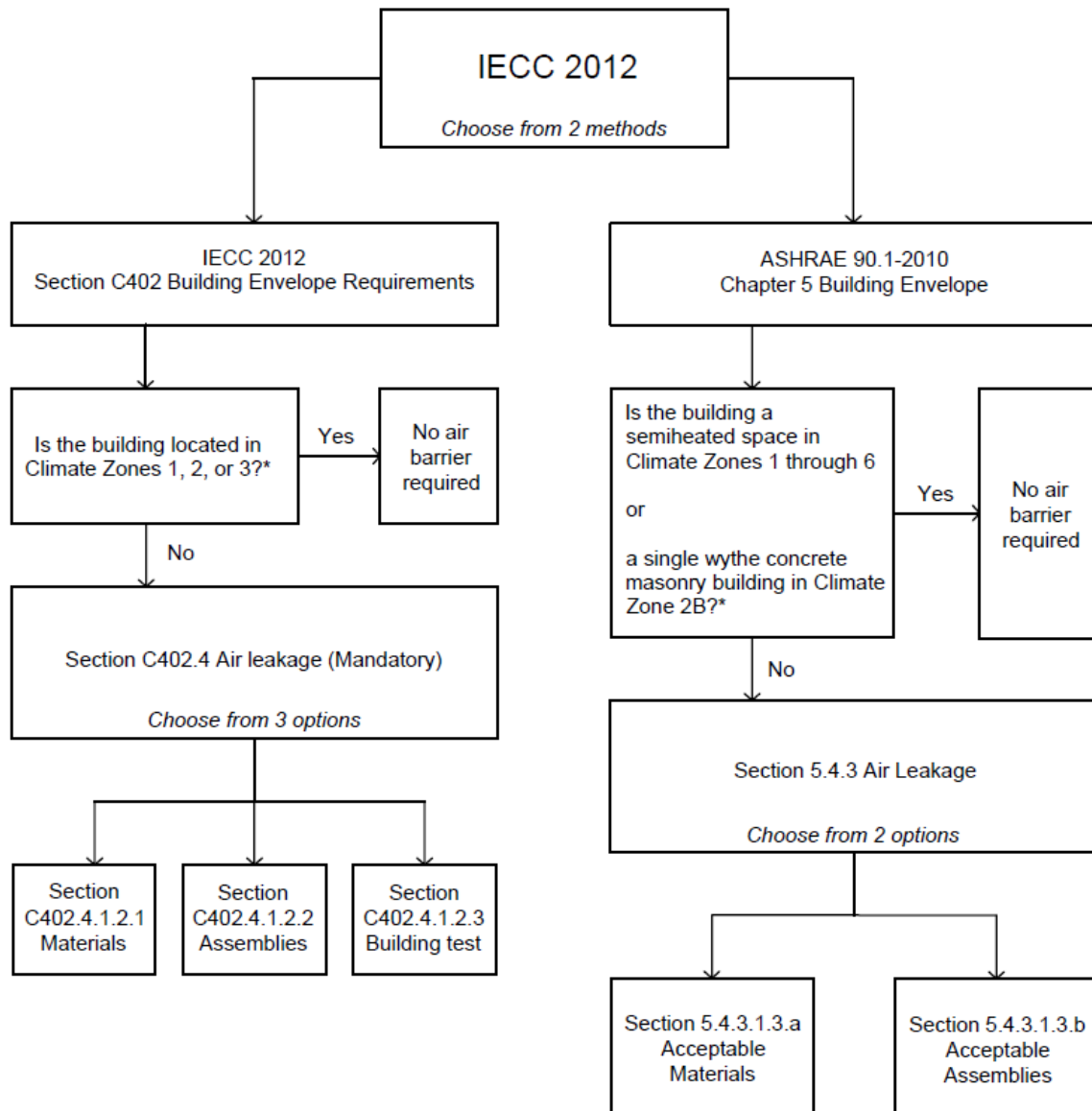
Determine which edition of IECC is required by local or state code and then refer to Figure 3 for IECC 2012 and Figure 4 for IECC 2015.

As previously noted, the air barrier-related requirements from the following IECC and ASHRAE 90.1 publications are contained in this section for reference:

- IECC 2012
- IECC 2015
- ASHRAE 90.1-2013 (same as 2010 edition)

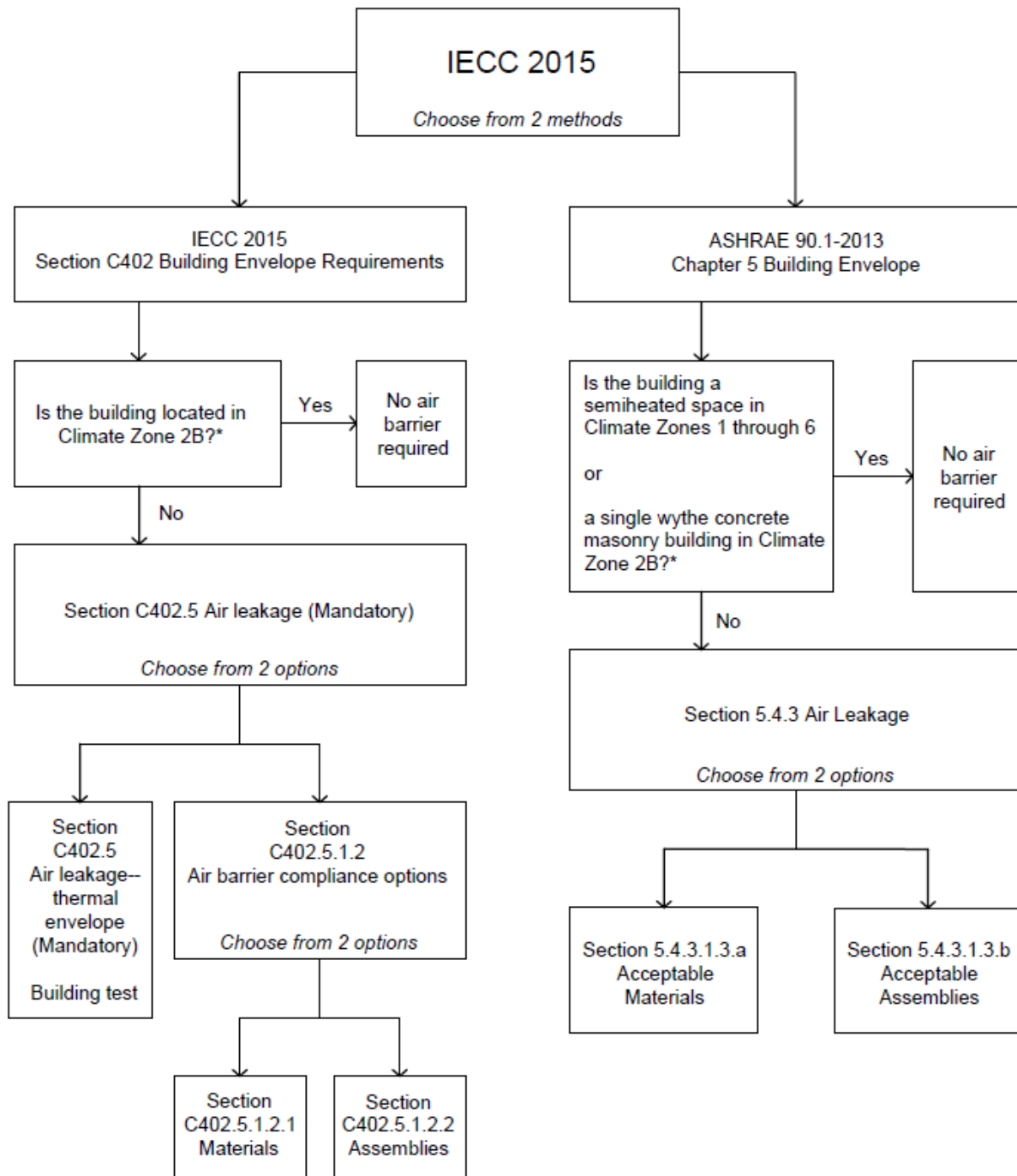
Commentary on air barrier requirements and reroofing information are also provided for IECC and ASHRAE 90.1.

Important note: *Designers need to follow the same energy code or standard when meeting the various requirements for a building project. For example, you cannot use IECC for the air barrier requirements and ASHRAE 90.1 for minimum thermal insulation requirements.*



* See Figure 5 on page 11 for U.S. climate zone map.

Figure 3: Compliance flow chart for IECC 2012



* See Figure 5 on page 11 for U.S. climate zone map.

Figure 4: Compliance flow chart for IECC 2015



International Energy Conservation Code, 2012 Edition (IECC 2012)

For commercial buildings, air barrier requirements are under Section C402—Building Envelope Requirements, Section C402.4 Air Leakage (Mandatory). This section states as follows:

“C402.4 Air leakage (Mandatory). The thermal envelope of buildings shall comply with Sections C402.4.1 through C402.4.8.

C402.4.1 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 C402.4.1.1 and C402.4.1.2.

Exception: Air barriers are not required in buildings located in Climate Zones 1, 2, and 3.

C402.4.1.1 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. Air barrier penetrations shall be sealed in accordance with Section C402.4.2. 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. Recessed lighting fixtures shall comply with Section C404.2.8. Where similar objects are installed which penetrate the air barrier, provisions shall be made to maintain the integrity of the air barrier.

Exception: Buildings that comply with Section C402.4.1.2.3 are not required to comply with Items 1 and 3.

C402.4.1.2 Air barrier compliance options. A continuous air barrier for the opaque building envelope shall comply with Section C402.4.1.2.1, C402.4.1.2.2, or C402.4.1.2.3.

C402.4.1.2.1 Materials. Materials with an air permeability no greater than 0.004 cfm/ft² (0.02 L/s • m²) under a pressure differential of 0.3 inches water gauge (w.g.) (75 Pa) when tested in accordance with ASTM E 2178 shall comply with this section. Materials in Items 1 through 15 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 $\frac{3}{8}$ inch (10 mm).
2. Oriented strand board having a thickness of not less than $\frac{3}{8}$ inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than $\frac{1}{2}$ inch (12 mm).

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4. Foil-back polyisocyanurate insulation board having a thickness of not less than $\frac{1}{2}$ inch (12 mm).
5. Closed cell spray foam a minimum density of 1.5 pcf (2.4 kg/m³) having a thickness of not less than $1\frac{1}{2}$ inches (36 mm).
6. Open cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m³) 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 $\frac{1}{2}$ inch (12 mm).
8. Cement board having a thickness of not less than $\frac{1}{2}$ inch (12 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 $\frac{5}{8}$ inch (16 mm).
13. Cast-in-place and precast concrete.
14. Fully grouted concrete block masonry.
15. Sheet steel or aluminum.

C402.4.1.2.2 Assemblies. Assemblies of materials and components with an average air leakage not to exceed 0.04 cfm/ft² (0.2 L/s • m²) under a pressure differential of 0.3 inches 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 and 2 shall be deemed to comply provided joints are sealed and requirements of Section C402.4.1.1 are met.

1. Concrete masonry walls coated with one application either of block filler and two applications of a paint or sealer coating;
2. A Portland cement/sand parge, stucco or plaster minimum $\frac{1}{2}$ inch (12 mm) in thickness.

C402.4.1.2.3 Building test. The completed building shall be tested and the air leakage rate of the building envelope shall not exceed 0.40 cfm/ft² at a pressure differential of 0.3 inches water gauge (2.0 L/s • m² at 75 Pa) in accordance with ASTM E 779 or an equivalent method approved by the code official.

C402.4.2 Air barrier penetrations. Penetrations of the air barrier and paths of air leakage shall be caulked, gasketed or otherwise sealed in a manner compatible with the construction materials and location. Joints and seals shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials shall be appropriate to the construction materials being sealed. 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.”

Commentary on IECC 2012

Section C402.4.1 Air barriers

This section provides general requirements for air barriers. An air barrier:

- Must be continuous throughout the building envelope (walls and roof).
- Can be located outside or inside the building envelope. It does not have to be in the same location in the wall and roof systems, as long as it is continuously sealed at the transition areas. An example is a roof membrane—located on the outside of the building envelope—and a wall air barrier membrane located inside a cavity wall.

Section C402.4.1 also includes an exception. Buildings located in Climate Zones 1-3 do not need to comply with the air barrier requirements. See Figure 5 for the U.S. climate zone map.

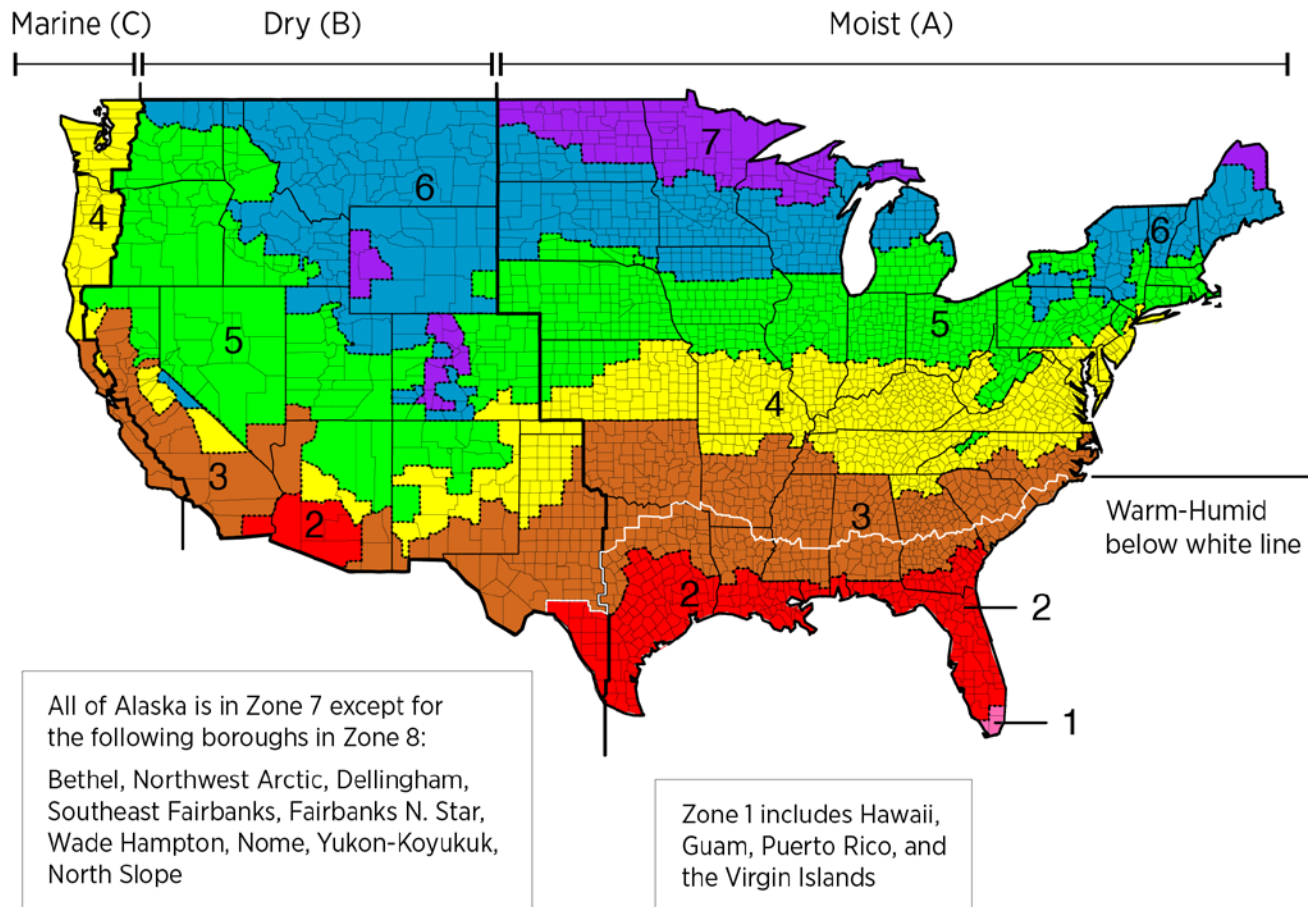


Figure 5: U.S. climate zone map
(Source: IECC)

Section C402.4.1.1 Air barrier construction

This section requires that the air barrier be continuous. The air barrier must be sealed at all seams and joints.

Section C402.4.2 Air barrier penetrations

This section requires that all penetrations be sealed. Membrane roof systems that are installed per the roofing manufacturer's installation instructions generally should meet the requirements of Section C402.4.2, since flashing details are meant to be weathertight.

Section C402.4.1.2 Air barrier compliance options

This section covers three options for showing compliance and are covered in the following sub-sections:

- Section C402.4.1.2.1 Materials
- Section C402.4.1.2.2 Assemblies
- Section C402.4.1.2.3 Building test

Section C402.4.1.2.1 Materials:

This option allows designers to show compliance by selecting air barrier materials that have an air permeability no greater than 0.004 cfm/ft² under a pressure differential of 0.3 inches water gauge (75 Pa) when tested in accordance with ASTM E2178, "Standard Test Method for Air Permeance of Building Materials." In order to show compliance, a designer should obtain an ASTM E2178 test report from the material manufacturer.

Some materials are automatically considered air barrier materials that meet the air permeability requirements. A list of these "deemed-to-comply" materials are provided below:

- Closed cell spray foam a minimum density of 1.5 pcf having a thickness of not less than 1½"
- Built up roofing membrane
- Modified bituminous roof membrane
- Fully adhered single-ply roof membrane

As long as these materials are installed in accordance with the manufacturer's instructions, an ASTM E2178 test report is not needed to demonstrate code compliance.

Section C402.4.1.2.2 Air Barrier Assemblies:

This option requires assemblies to be tested per three ASTM air leakage test standards. These ASTM standards are applicable to wall assemblies and not roofing assemblies; therefore, this option is not applicable to roof system designers.

Section C402.4.1.2.3 Building test:

This option involves air leakage testing after building construction. In order to show compliance, the completed building should be tested in accordance with ASTM E779, "Standard Test Method for Determining Air Leakage Rate by Fan Pressurization."

C402.4.2 Air barrier penetrations

This section includes the requirement to seal penetrations and other paths of air leakage in a manner “compatible with the construction materials and location.” Seals are required to have the ability to resist positive and negative pressure from “wind, stack effect and mechanical ventilation.”

Roof system designers should include penetration sealing details as part of construction documents to demonstrate compliance with the Section C402.4.2 requirements.

Reroofing

Specific air barrier requirements for reroofing projects are not addressed in IECC 2012. However additions, alterations, renovations or repairs are referenced in Chapter 1 Scope and Administration, Section 101.4.3 Additions, alterations, renovations or repairs. It reads as follows:

“C101.4.3 Additions, alterations, renovations or repairs. Additions, alterations, renovations or repairs to an existing building, building system or portion thereof shall conform to the provisions of this code as they relate to new construction without requiring the unaltered portion(s) of the existing building or building system to comply with this code.”

Section 101.4.3 also has a list of exceptions where you do not need to comply with the current code provided the building's energy use is not increased. Exceptions 4 and 5 apply specifically to certain reroofing situations:

- “4. Construction where the existing roof, wall or floor cavity are not exposed.
5. Reroofing for roofs where neither the sheathing nor the insulation is exposed. Roofs without insulation in the cavity and where the sheathing or insulation is exposed during reroofing shall be insulated either above or below the sheathing.”

Exceptions 4 and 5 seem to indicate the following:

- If a reroofing situation involves the tear-off of an existing roof system, i.e., exposing the roof deck and installing a new roof system, the new roof system will have to comply with IECC 2012.
- If a reroofing project involves a roof re-cover, i.e., the existing roof system remains in place, the new roof system does not have to comply with IECC 2012.

It is recommended designers discuss air barrier requirements with local code officials prior to reroofing projects.

IECC 2015 Air Barrier Requirements

For commercial buildings, air barrier requirements are under Section C402—Building Envelope Requirements, Section C402.5 Air leakage—thermal envelope (Mandatory). This section states as follows:

“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/ft² (0.2 L/s • m²). 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.

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.

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/ft² (0.02 L/s • m²) 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 $\frac{3}{8}$ inch (10 mm).
2. Oriented strand board having a thickness of not less than $\frac{3}{8}$ inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than $\frac{1}{2}$ inch (12 mm).
4. Foil-back polyisocyanurate insulation board having a thickness of not less than $\frac{1}{2}$ inch (12 mm).
5. Closed-cell spray foam a minimum density of 1.5 pcf (2.4 kg/m³) having a thickness of not less than 1½ inches (38 mm).
6. Open-cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m³) 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 $\frac{1}{2}$ inch (12 mm).
8. Cement board having a thickness of not less than $\frac{1}{2}$ inch (12 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 $\frac{5}{8}$ inch (16 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.

C402.5.1.2.2 Assemblies. Assemblies of materials and components with an average air leakage not greater than 0.04 cfm/ft² (0.2 L/s • m²) 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."

Commentary on IECC 2015

Section C402.5 Air leakage—thermal envelope (Mandatory).

This section contains the requirement that a building envelope must comply with air leakage requirements. There are two options to show compliance:

- Option 1: The building envelope should be tested after building construction in accordance with ASTM E779, “Standard Test Method for Determining Air Leakage Rate by Fan Pressurization.”
- Option 2: The building envelope should be in compliance with Sections C402.5.1 through C402.5.8. Roofing-related provisions are in Section 402.5.1.2 Air barrier compliance options. Within Section 402.5.1.2 are two ways to show compliance (see page 17 for further discussion).

Section C402.5 also provides general requirements for air barriers. An air barrier:

- Must be continuous throughout the building envelope (walls and roof).
- Can be located outside or inside the building envelope. It does not have to be in the same location in the wall and roof systems, as long as it is continuously sealed at the transition areas. An example is a roof membrane—located on the outside of the building envelope—and a wall air barrier membrane located inside a cavity wall.

Section C402.5.1 includes an exception. Commercial buildings located in Climate Zone 2B do not have to have an air barrier.

Important Note: *This is different from IECC 2012 where Climate Zones 1-3 were exempt. Refer to Figure 5 on page 11 of this Guide for the U.S. climate zone map.*

C402.5.1.1 Air barrier construction

This section provides general requirements for air barriers. An air barrier must be constructed to comply with the following:

- It must be continuous throughout the building envelope.
- All seams and joints should be sealed.
- Penetrations should be caulked, taped, gasketed or sealed. Sealing materials should be appropriate to the construction materials. Seals are required to have the ability to resist positive and negative pressure from “wind, stack effect and mechanical ventilation.” Membrane roof systems that are installed per the roofing manufacturer’s installation instructions generally should meet the requirements of Section C402.5.1.1, since flashing details are meant to be weathertight.

C402.5.1.2 Air barrier compliance options

This section covers Option 2 of the two options discussed in Section C402.5 Air leakage—thermal envelope (Mandatory).

When using this option, designers have two choices to show compliance. Air barriers must be constructed by materials or assemblies meeting certain criteria. The criteria can be found in:

- C402.5.1.2.1 Materials
- C402.5.1.2.2 Assemblies

Section C402.4.1.2.1 Materials:

Section C402.4.1.2.1 allows designers to show compliance by selecting air barrier materials that have an air permeability no greater than 0.004 cfm/ft² under a pressure differential of 0.3 inches water gauge (75 Pa) when tested in accordance with ASTM E2178, “Standard Test Method for Air Permeance of Building Materials.” In order to show compliance, a designer should obtain an ASTM E2178 test report from the material manufacturer.

This option also considers materials that are automatically considered as air barrier materials meeting the air permeability requirements. A list of these “deemed-to-comply” materials are provided below:

- Closed cell spray foam a minimum density of 1.5 pcf having a thickness of not less than 1½”
- Built up roofing membrane
- Modified bituminous roof membrane
- Fully adhered single-ply roof membrane

As long as these materials are installed in accordance with the manufacturer’s instructions, an ASTM E2178 test report is not needed to demonstrate code compliance.

C402.5.1.2.2 Assemblies:

C402.5.1.2.2 requires air barrier assemblies to be tested per three ASTM air leakage test standards. These ASTM standards are applicable to wall assemblies and not roofing assemblies; therefore, this option is not applicable to roof system designers.

Reroofing

IECC 2015 specifically notes that air barrier requirements do not apply for most reroofing projects.

A new chapter, Chapter 5 Existing Buildings, was added to IECC 2015. Reroofing is covered in Section C503 Alterations. This section contains a list of alterations that do not need to comply with the requirements for new construction, provided the energy use of the building is not increased. The roofing-related items are as follows:

- “5. Roof recover
6. Air barriers shall not be required for roof recover and roof replacement where the alterations or

renovations to the building do not include alterations, renovations or repairs to the remainder of the building envelope”

Thus any reroofing projects, re-covers or replacements, do not need to meet air barrier requirements unless the scope of work also includes alterations to the remainder of the building envelope.

This exception is also referenced in Section C504 Repairs:

“3. Air barriers shall not be required for roof repair where the repairs to the building do not include alterations, renovations or repairs to the remainder of the building envelope”

ASHRAE 90.1, 2013 Edition Air Barrier Requirements

In the 2012 and 2015 editions of IECC, there is an alternative path for building designers to show compliance (see flow charts in Figures 3 and 4 on pages 7 and 8, respectively). Designers may use ASHRAE 90.1, “Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE 90.1). IECC 2012 references the 2010 edition of ASHRAE 90.1 and IECC 2015 references the 2013 edition of ASHRAE 90.1. The roofing-related provisions are virtually identical in both ASHRAE editions, so the information provided below is from the 2013 edition.

Important note: Designers need to follow the same energy code or standard when meeting the various requirements for a building project. For example, you cannot use IECC for the air barrier requirements and ASHRAE 90.1 for minimum thermal insulation requirements.

Air barrier requirements are covered in Chapter 5 Building Envelope, Section 5.4.3 Air Leakage. This section states as follows:

“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:

- a. Semiheated spaces in climate zones 1 thru 6.
- b. Single wythe concrete masonry buildings in climate zone 2B

5.4.3.1.1 Air Barrier Design. The 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 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, exterior walls, and ceiling or 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 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, between walls and roofs or ceilings.
- c. Penetrations through the 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 air barrier materials.

5.4.3.1.3 Acceptable Materials and Assemblies. Continuous air barrier materials and assemblies for the opaque building envelope shall comply with one of the following requirements:

- a. Materials that have an air permeance not exceeding 0.004 cfm/ft² under a pressure differential of 0.3 in. H₂O (1.57 psf) when tested in accordance with ASTM E2178. The following materials meet the requirements of 5.4.3.1.3 a:

1. Plywood—minimum $\frac{3}{8}$ in.
2. Oriented strand board—minimum $\frac{3}{8}$ in.
3. Extruded polystyrene insulation board—minimum $\frac{1}{2}$ in.
4. Foil-faced urethane insulation board—minimum $\frac{1}{2}$ in.
5. Exterior gypsum sheathing or interior gypsum board—minimum $\frac{1}{2}$ in.
6. Cement board—minimum $\frac{1}{2}$ 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 $\frac{1}{2}$ in.
11. Cast-in-place and precast concrete
12. Sheet metal
13. Closed cell 2 lb/ft³ nominal density spray polyurethane foam—minimum 1 in.

- b. Assemblies of materials and components (sealants, tapes, etc.) that have an average air leakage not to exceed 0.04 cfm/ft² under a pressure differential of 0.3 in H₂O (1.57 psf) when tested in accordance with ASTM E2357, ASTM E1677, ASTM E1680, or ASTM E283; The following assemblies meet these requirements:

1. Concrete masonry walls that are
 - i. Fully grouted, or
 - ii. Painted to fill the pores.”

Commentary on ASHRAE 90.1

Section 5.4.3.1 Continuous Air Barrier

This section contains the requirement that the entire building envelope must have an air barrier. This section also contains some exceptions, including:

- Semi-heated spaces in Climate Zones 1 through 6 (see map on page 11); and
- Single wythe concrete masonry buildings in Climate Zone 2B.

ASHRAE 90.1 defines a “semi-heated space” as “an enclosed space within a building that is heated by a heating system whose output capacity is greater than or equal to 3.4 Btu/h • ft² of floor area but is not a conditioned space.”

5.4.3.1.1 Air Barrier Design

This section contains the requirement for air barrier documentation. All air barrier components of each building envelope assembly shall be clearly identified or otherwise noted on construction documents. This section also includes the requirement to seal interconnections and penetrations. The air barrier must have the ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation.

5.4.3.1.2 Air Barrier Installation

This section covers air barrier installation. The air barrier should be continuous and installed in an approved manner to minimize air leakage. While ASHRAE 90.1 contains material and assembly air barrier compliance requirements that are similar as IECC, there is no building air leakage test option.

5.4.3.1.3 Acceptable Materials and Assemblies

This option considers materials that are automatically considered as air barrier materials meeting the air permeability requirements, similar to IECC. A list of these “deemed-to-comply” materials are provided below:

- Built up roofing membrane
- Modified bituminous roof membrane
- Fully adhered single-ply roof membrane
- Closed cell 2 lb/ft³ nominal density spray polyurethane foam—minimum 1 in.

As long as these materials are installed in accordance with the manufacturer’s instructions, an ASTM E2178 test report is not needed to demonstrate code compliance.

Important Note: *The 2016 edition of ASHRAE 90.1 has been published and there was a change to Item 9 in the deemed-to-comply list. “Fully adhered” was removed from “single-ply roof membrane.” Therefore, when using ASHRAE 90.1-2016, all single-ply roof membranes, no matter how they are installed, are considered deemed-to-comply.*

Reroofing

ASHRAE 90.1 does not address reroofing. Verify with the building code official where the building is located to determine requirements for a reroofing project.

Guidance for Roofing Professionals

The following are some additional guidelines for roofing professionals on projects involving air barriers.

Project Recommendations

The opportune time to address air barriers is in the design and pre-construction phases of a project. In other words, the time to discuss air barriers is before construction begins, not during construction.

Design phase

For new construction, it is the responsibility of the building's design professional to:

- Determine the need for an air barrier.
- Provide details on sealing joints, penetrations, transition areas, etc. IECC requires that all air barrier components of each building envelope assembly should be clearly identified and/or otherwise noted on construction documents.
- Verify an air barrier's compatibility with other materials.

In new construction projects, or if there is an architect or design professional involved in a roofing project, the design of an air barrier system is outside a roofing contractor's scope of work.

However in reroofing situations, often there is not a design professional. If that is the case, the roofing contractor is responsible for the air barrier system if it is required by the energy code: e.g., a tear-off and replacement reroofing project needing to comply with IECC 2012.

Pre-construction phase

An air barrier system is one of the few building systems that involves the coordination of many different trades. Before construction starts, a pre-construction meeting should occur with all parties involved with the design and installation of the air barrier system. Typically, this would include:

- General Contractor
- Building Owner
- Owner's Representative
- Architect
- Air Barrier Manufacturer
- Air Barrier Contractor
- Roofing Contractor
- Waterproofing Contractor
- Insulation Contractor
- Carpenter
- Drywall Contractor
- Window Contractor
- Concrete Contractor
- Masonry Contractor

A pre-construction meeting is a good opportunity for the roofing contractor to be involved with the air barrier discussion.

The discussion should include:

- A review of the drawings and specifications, especially the transition and tie-in areas
- A review of the materials and accessories that covers which party is responsible for each material/system and any compatibility issues
- A discussion of the sequencing of the work of all trades in order to determine a construction schedule
- A discussion of coordinating an assembly mock-up, if required for the project

Continuous air barrier concepts

In order to participate in air barrier discussions, roofing professionals should be familiar with the following:

- The concept of membrane roof system used as an air barrier in a building envelope.
- The importance of keeping the air barrier continuous in a building envelope.

To assist roofing professionals in visualizing these concepts, examples of hypothetical building conditions are provided.

Important note: *These figures are meant to illustrate conceptually how a roof membrane should be sealed to the wall air barrier to make an air barrier continuous. They should not be considered construction details.*

Figures 6, 7 and 8 are scenarios where the wall air barrier is a membrane or coating system installed on the structural backup wall and the membrane roof system serves as the roof air barrier. In these examples, the membrane roof system is sealed to the wall air barrier to keep the air barrier continuous.

Figures 9 and 10 are scenarios where an exterior insulation sheathing board serves as the wall air barrier. This type of construction is where a layer of “continuous insulation” is desired on a wall system. In these examples, the membrane roof system is sealed to the exterior insulation sheathing board to keep the air barrier continuous.

Figures 11 and 12 are scenarios where the wall cladding serves as the wall air barrier. In these examples, the membrane roof system is sealed to the wall cladding to keep the air barrier continuous.

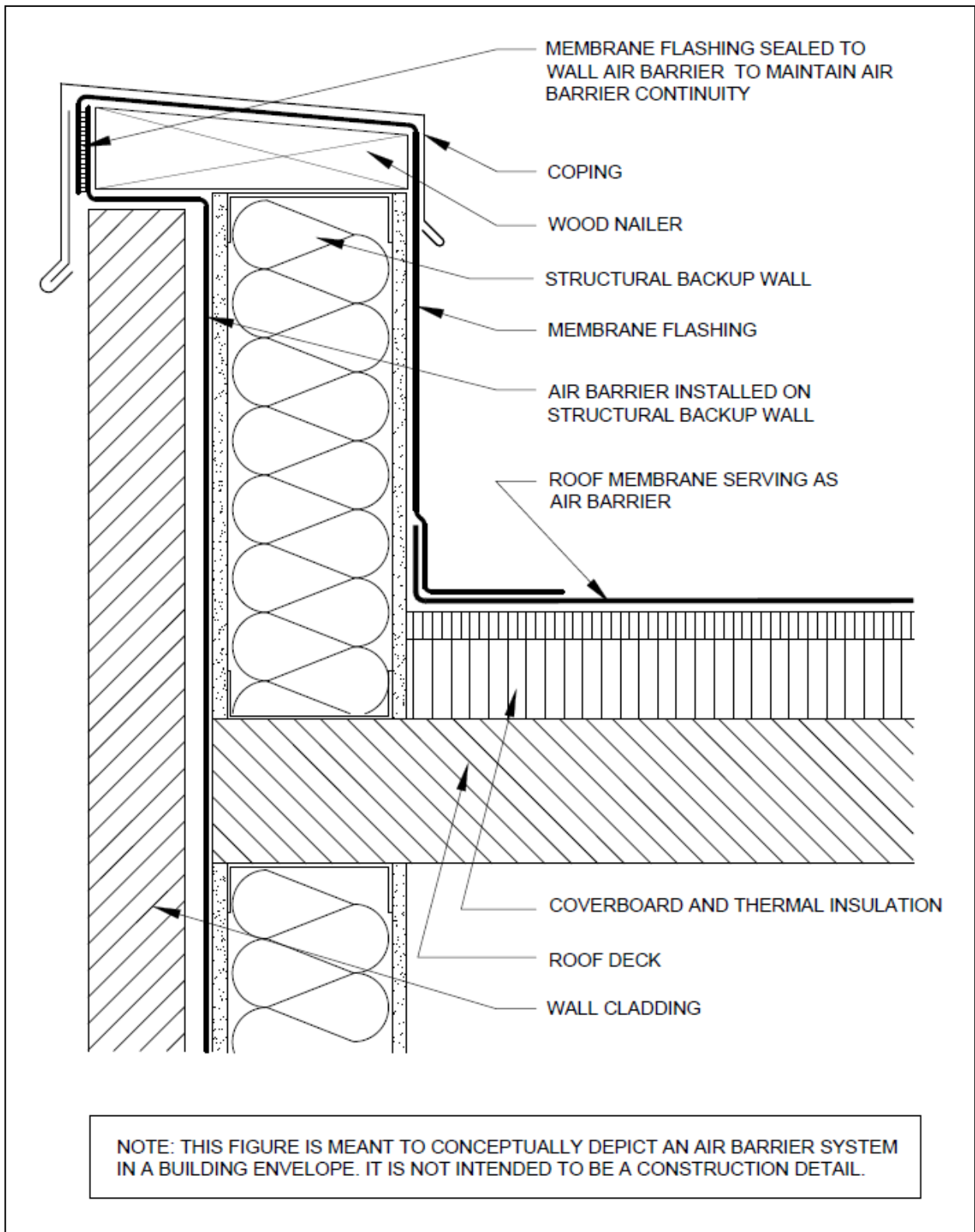


Figure 6: Hypothetical parapet condition where the wall air barrier is a membrane installed on the structural wall and the continuous air barrier wraps the nailer under the coping.

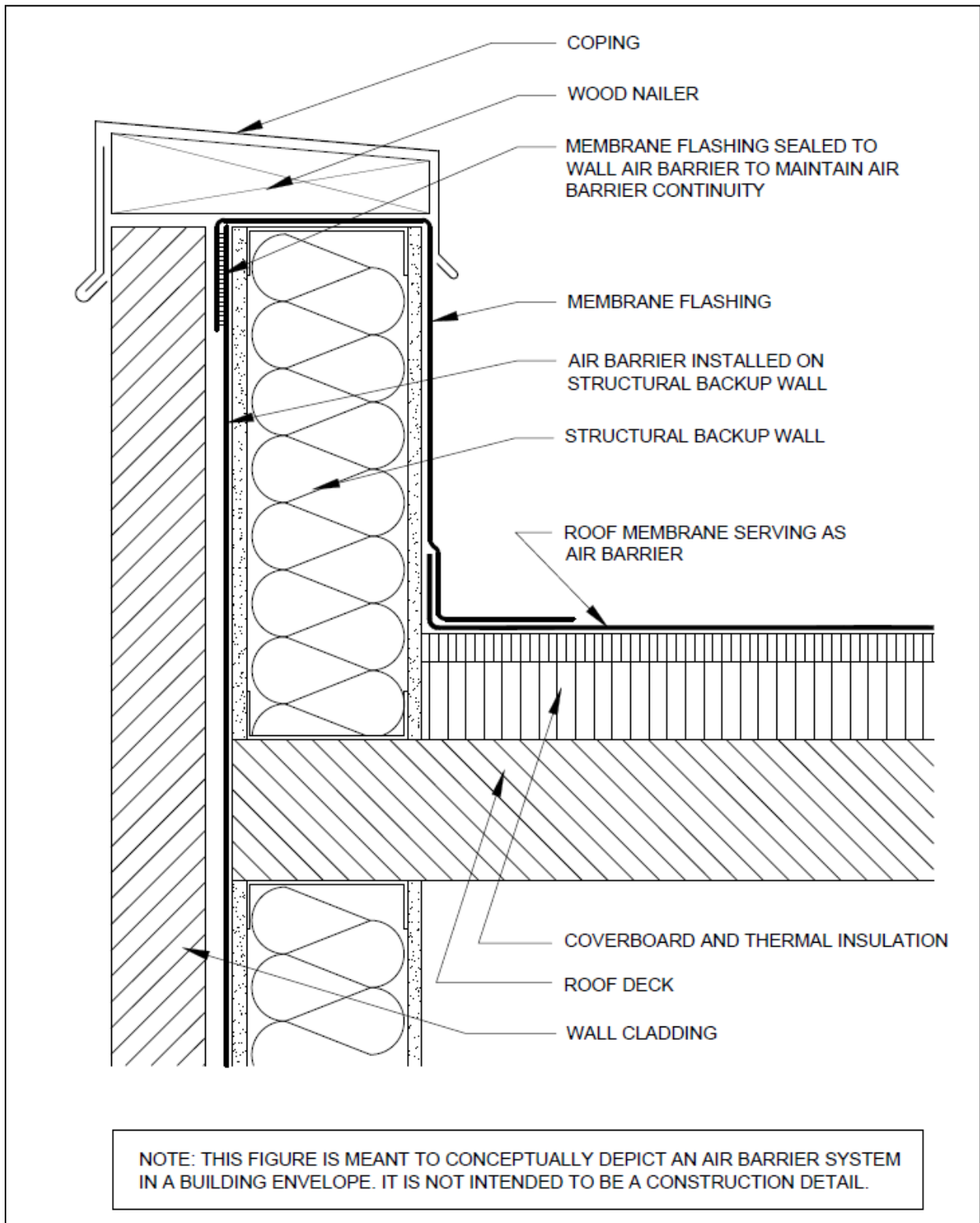


Figure 7: Hypothetical parapet condition where the wall air barrier is a membrane installed on the structural backup wall under the coping and wood nailer.

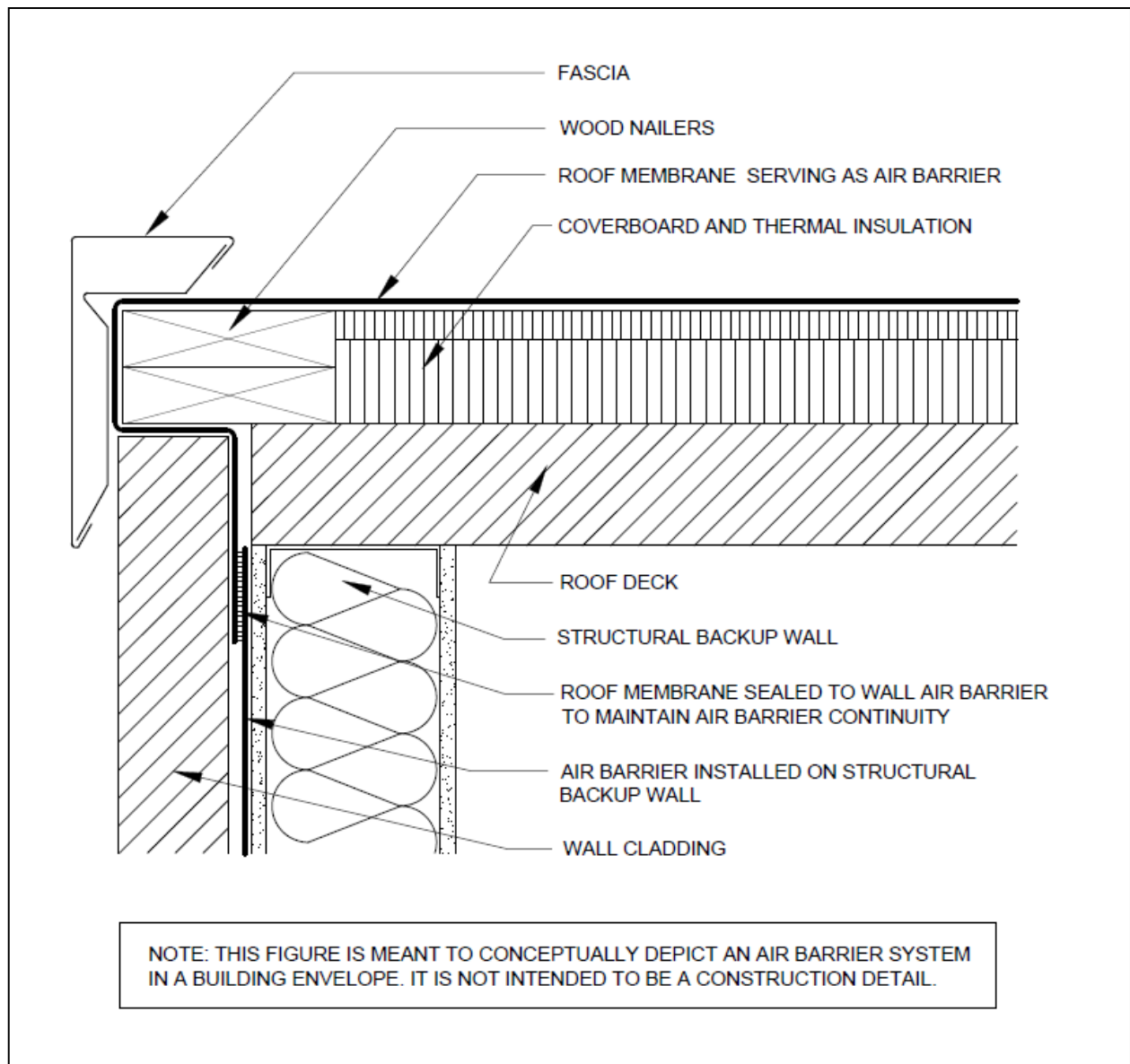


Figure 8: Hypothetical perimeter edge condition where the wall air barrier is a membrane installed on the structural backup wall

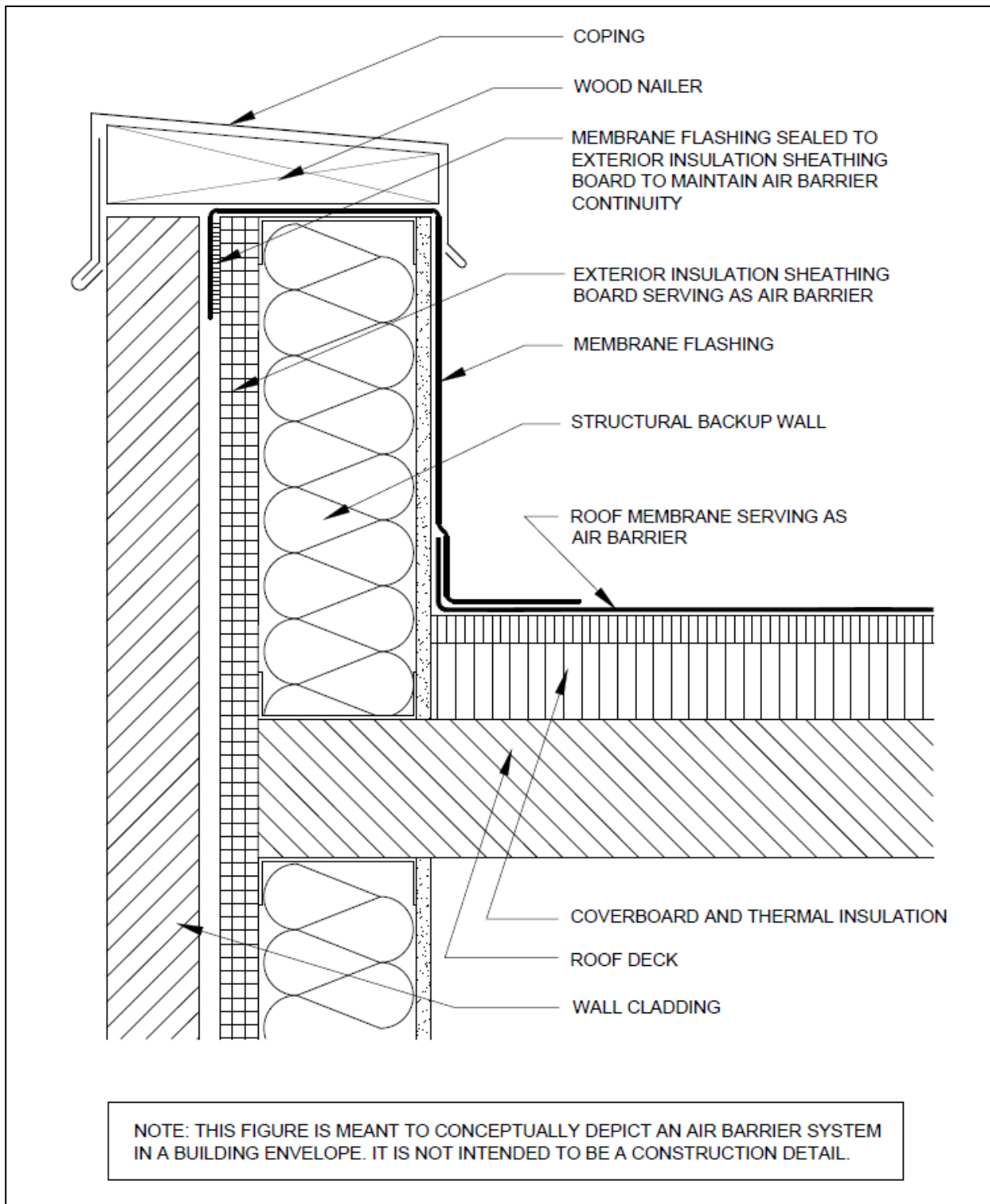


Figure 9: Hypothetical parapet condition where the wall air barrier is an exterior insulation sheathing board

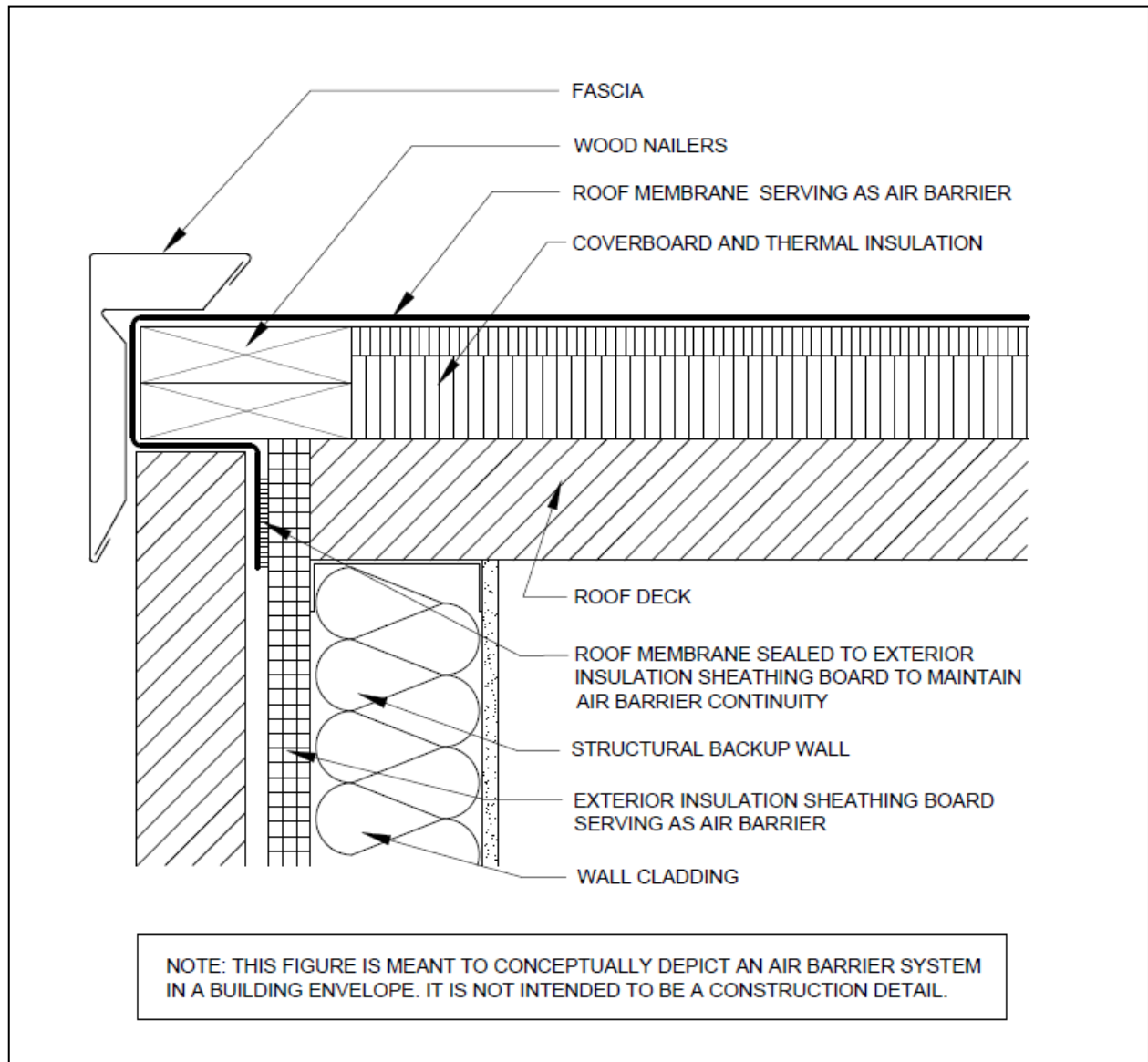
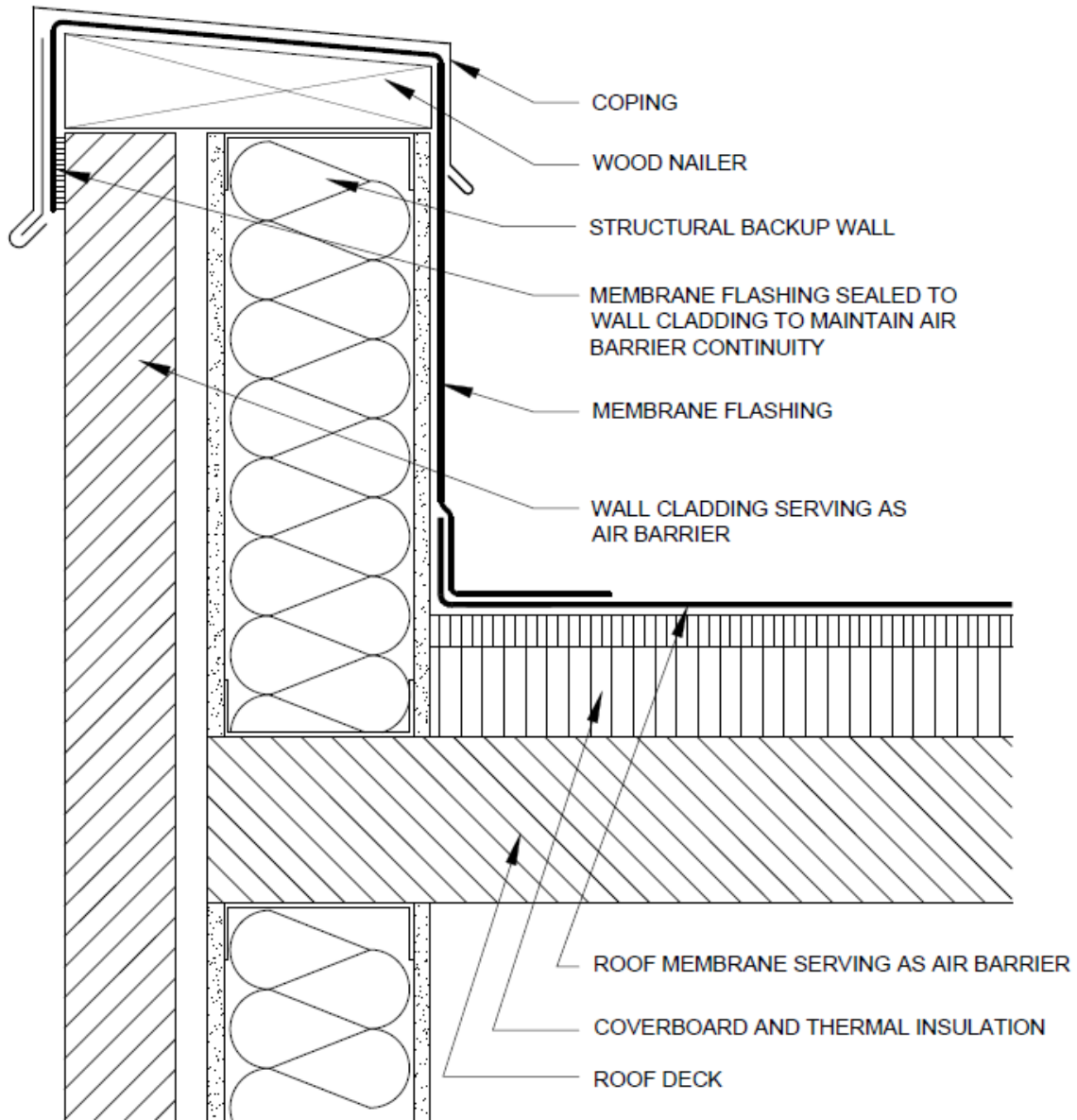


Figure 10: Hypothetical perimeter edge condition where the wall air barrier is an exterior insulation sheathing board



NOTE: THIS FIGURE IS MEANT TO CONCEPTUALLY DEPICT AN AIR BARRIER SYSTEM IN A BUILDING ENVELOPE. IT IS NOT INTENDED TO BE A CONSTRUCTION DETAIL.

Figure 11: Hypothetical parapet condition where the wall air barrier is the wall cladding

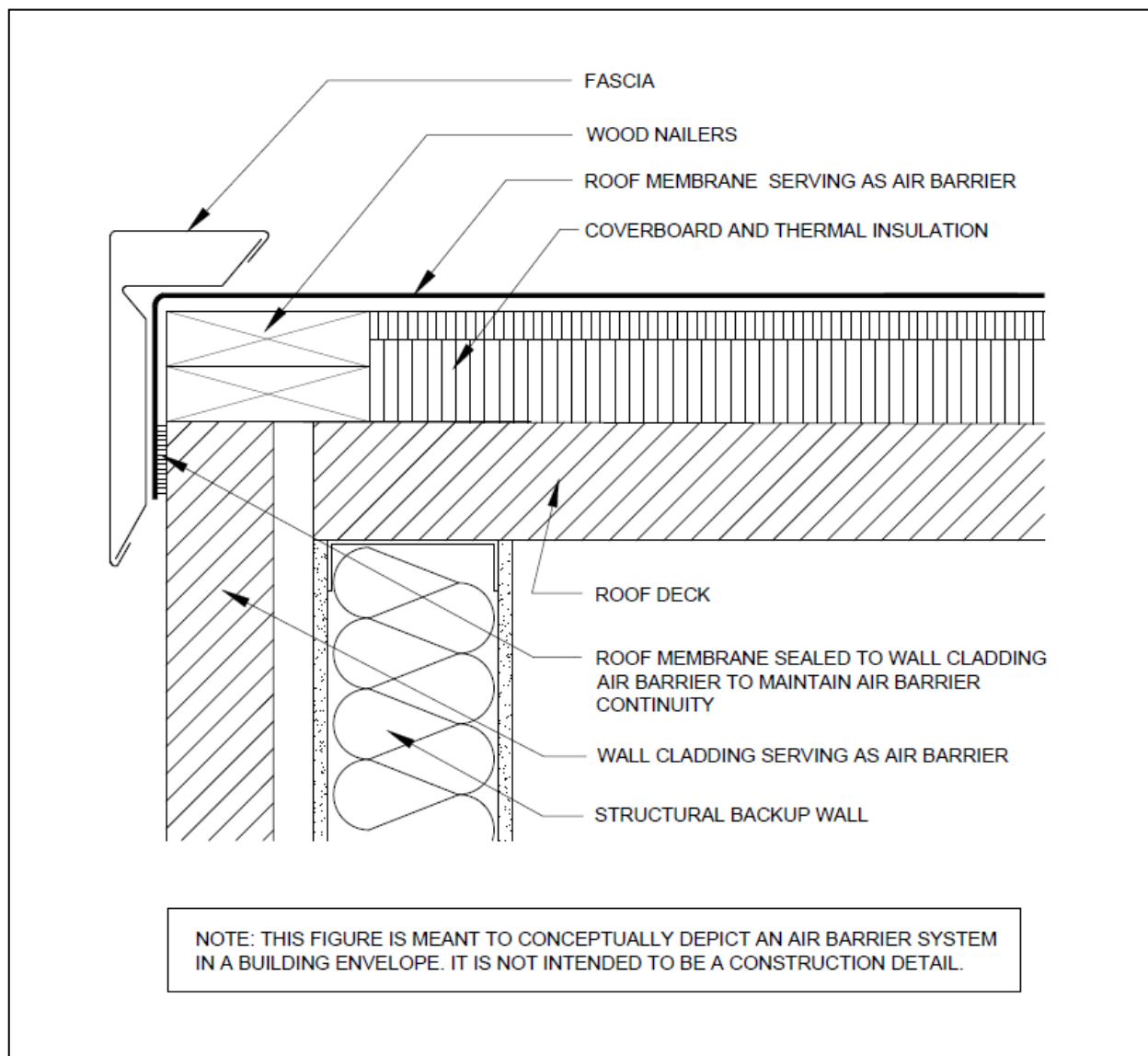


Figure 12: Hypothetical perimeter edge condition where the wall air barrier is the wall cladding

Deemed-to-comply GAF Products

The following GAF products meet the “deemed-to-comply” list of air barrier materials in the energy codes and standards:

- EverGuard® TPO Membranes, adhered applications
- EverGuard® Fleece-back TPO Membranes, adhered applications
- EverGuard Extreme® TPO Membranes, adhered applications
- EverGuard Extreme® TPO Fleece-back Membranes, adhered applications
- EverGuard® Freedom™ TPO HW Membranes
- EverGuard® Freedom™ TPO with RapidSeam™ Membranes
- EverGuard® PVC Membranes, adhered applications
- EverGuard® PVC Fleece-back Membranes, adhered applications
- EverGuard® PVC XK Membranes, adhered applications
- EverGuard® PVC XK Fleece-back Membranes, adhered applications
- Built-up roof systems (BUR) with GAFGLAS® felts
- Modified bitumen roof systems with RUBEROID® Modified Bitumen APP Membranes
- Modified bitumen roof systems with RUBEROID® Modified SBS Membranes
- Modified bitumen roof systems with Liberty® SBS Self-adhering Membranes

Important Note: Per the 2016 edition of ASHRAE 90.1, mechanically-attached single-ply roof systems are also deemed-to-comply.

Tested-to-comply GAF Product

Materials not on the “deemed-to-comply” list, such as mechanically-attached single-ply roof membranes, can still be used as an air barrier. However, they need to be tested for air permeability requirements when using the following compliance methods:

- IECC 2012, Section C402.4.1.2.1 Materials
- IECC 2015, Section C402.5.1.2.1 Materials
- ASHRAE 90.1-2010, Section 5.4.3.1.3 Acceptable Materials and Assemblies
- ASHRAE 90.1-2013, Section 5.4.3.1.3 Acceptable Materials and Assemblies

In order to be compliant, the membrane material must have an air permeability no greater than 0.004 cfm/ft² (0.02 L/s • m²) under a pressure differential of 0.3 inches water gauge (w.g.) (75 Pa) when tested in accordance with ASTM E2178. Compliance is verified by a third-party testing agency’s report.

The following GAF products have been “tested-to-comply” and may be used as an air barrier material when mechanically attached:

- EverGuard® TPO Membrane
- EverGuard Extreme® TPO Membrane
- EverGuard® PVC Membrane
- EverGuard® PVC XK Membrane

Contact GAF Technical Services 800-ROOF-411 (800-766-3411) if you need documentation to confirm compliance to the test standard.

References

This section contains the following:

- Applicable standards
- Other resources
- Glossary

Applicable standards

There are two organizations that have standards applicable to air barriers:

- American Society for Testing and Materials (ASTM)
- Underwriters Laboratories of Canada (ULC)

ASTM Standards

ASTM E283, “Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.” This test method covers a standard laboratory procedure for determining the air leakage rates of exterior windows, curtain walls, and doors under specified differential pressure conditions across the specimen. The test method described is for tests with constant temperature and humidity across the specimen.

ASTM E779, “Standard Test Method for Determining Air Leakage Rate by Fan Pressurization.” This test method measures air-leakage rates through a building envelope under controlled pressurization and depressurization. This test method is sometimes referred to as the “blower door test.”

ASTM E1677, “Standard Specification for an Air Barrier (AB) Material or System for Low-Rise Framed Building Walls.” This specification covers minimum performances and specification criteria for an air barrier (AB) material or system for framed walls of low-rise buildings.

ASTM E2178, “Standard Test Method for Air Permeance of Building Materials.” This test method is to determine the air permeance of building materials at various pressure differentials with the intent of determining an assigned air permeance rate of the material at the reference pressure difference (ΔP) of 75 Pa.

The method can be used to assess flexible sheet or rigid panel-type materials using a 1-m by 1-m specimen size. The test method addresses the air permeance of the material being tested and does not address the testing of substrates or attachment components such as adhesive or mechanical fasteners.

ASTM E2357, “Standard Test Method for Determining Air Leakage of Air Barrier Assemblies.” This method is intended to simulate the performance of various air barrier materials/accessories when combined into an assembly. Based upon the results of the measurements, this procedure then assigns an air leakage rating for the air barrier assembly.

ULC Standards

CAN/ULC-S742, “Standard for Air Barrier Assemblies—Specification.” The test methods described in this standard involve measuring the air leakage rate of a representative test specimen of an air barrier assembly before and after exposure to wind pressure loading cycles and then determining an air leakage rate at a reference pressure difference, based on the measurements.

The standard establishes minimum performance requirements for the air leakage rate of air barrier assemblies based upon levels of air leakage rate and wind pressure loading. Five classifications based upon air leakage rate are provided in Figure 13.

Classification	Air leakage rate ¹
A1	0.05 L/(s·m ²)
A2	0.10 L/(s·m ²)
A3	0.15 L/(s·m ²)
A4	0.20 L/(s·m ²)
A5	0.50 L/(s·m ²)
¹ Maximum reference air leakage rate at a pressure difference of 75 Pa.	

Figure 13: Air leakage rates by classification

Note that CAN/ULC-S742 Classification A4, with a reference air leakage rate not exceeding 0.20 L/(s·m²), correlates to the U.S. value of 0.04 cfm/ft².

Other Resources

The following organizations have information on air barriers:

Air Barrier Association of America (ABAA)

An association of manufacturers, suppliers, distributors, architects, engineers, contractors, researchers, testing and audit agencies, consultants and building owners representing the air barrier industry. They provide air barrier information at www.airbarrier.org.

Building Science Corporation

Building Science Corporation is a building science consulting and architecture firm that specializes in building technology consulting for all buildings types. They provide articles and papers on air barriers at buildingscience.com.

National Roofing Contractors Association (NRCA)

NRCA is a trade association for roofing contractors. Air barrier information is available in *The NRCA Roofing Manual: Architectural Metal Flashing, Condensation and Air Leakage Control, and Reroofing*.

Glossary

Air barrier: Materials assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or a combination of materials.

Air barrier accessory: A transitional component of the air retarder that provides continuity.

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.

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

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.

Air retarder: A term often used interchangeably with “air barrier.” See “air barrier.”

Building (thermal) envelope: The basement walls, exterior walls, floor, roof and any other building elements that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space.

Commercial building: A building that is not one of the following:

- Detached one- and two-story dwellings
- Multiple single family dwellings (townhouses)
- Residential Group R-2, R-3 and R-4 buildings less than 3 stories in height above grade

Refer to Section 310—Residential Group R of the International Building Code (IBC) for definitions of residential groups.

Conditioned space: An area, room or space that is enclosed within the building thermal envelope and is directly or indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate through openings with conditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or cooling.

Continuous air barrier: A combination of materials and assemblies intended to reduce or control the passage of air through a building thermal envelope.

Re-cover: The process of installing an additional roof covering over a prepared existing roof covering without removing the existing roof covering.

Replacement: The process of removing the existing roof covering, repairing any damaged substrate and installing a new roof covering; also known as "tear-off and replacement."

Reroofing: The process of recovering or replacing an existing roof covering. See "re-cover" and "replacement."

Unconditioned space: An enclosed space that is not conditioned or semi-heated space (such as crawlspaces, attics and parking garages).

Vapor retarder: A material or system intended to reduce water vapor transmission.

Water vapor permeance: The time rate of water vapor transmission through unit area of flat material or construction induced by unit vapor pressure difference between two specific surfaces, under specified temperature and humidity conditions. Permeance is a performance evaluation and not a property of a material.