Controlling Moisture in Unvented Attics - Code Compliance Brief

Overview:

The intent of this brief is to provide code-related information about controlling moisture in unvented attics by installing a vapor diffusion port/vent that would convey water vapor from an unvented attic to the outside when air-permeable insulation materials are installed and can be verified as being in compliance with the related codes and standards for residential construction. Providing consistent information to document compliance with codes and standards to all relevant parties responsible for verifying compliance (e.g., code officials, builders, contractors, designers, etc.) is expected to result in increased compliance and more timely, less challenging and more uniform plan review and field inspections.

In the early 1990s, construction of unvented attics became popular, especially for structures in warmer climates. The typical construction scenario involved the use of low-density, open-cell spray foam insulation for the thermal barrier at roof deck and duct work installed in the unvented attic space. Most of these attics stayed dry. “These were conditioned attics,” said Joe Lstiburek, Building Science Corporation, CEO. [1] “The conditioning was happening because of leaky ductwork. The supply ducts were leaking, and there was a leaky ceiling.” The attics were accidentally heated during the winter and accidentally cooled during the summer by air escaping through cracks in the duct seams. This type of conditioning kept attic moisture levels under control. Lstiburek continued, “Later, when the ductwork got tighter, we ended up with very high humidity in the attics, and we discovered sweating on the ducts and mold on the mastic.”

In summary, Lstiburek’s explanation was that moisture in the attic originated inside the house. Moisture ended up in the attic rather than in the lower floors of the house through a phenomenon known as “hygric buoyancy.” This phenomenon occurs when moisture-laden air is lighter and less dense than dry air so the moisture-laden air collects in the attic.

After Dr. Lstiburek identified this moisture problem, further investigation revealed what the recent codes addressed or did not address and whether or not the codes needed to be changed. The study revealed that proper moisture, ventilation, and insulation requirements in climate zones 1, 2, and 3 for unvented attics and unvented enclosed rafter assemblies are not addressed in the 2015 International Energy Conservation Code (IECC). These measures are identified as code barriers because they are neither discouraged nor encouraged by the recent model codes (i.e., IECC). Moisture, ventilation, and insulation requirements are addressed for unvented attics in the International Residential Code (IRC), but only for air-impermeable insulation[2] or rigid board insulation installed above roof decks.

Through the Building America Program, new approaches have successfully been researched and validated. The Building America research team, Building Science Corporation, submitted separate proposals for the 2018 International Code Council (ICC) code hearings to address the moisture, ventilation, and insulation issues in unvented attics with interior insulation. The code proposals include new language about installing a vapor diffusion port/vent that would convey water vapor from an unvented attic to the outside when air-permeable insulation materials are installed. Some of the main reasons for the new code changes are described below:

- The research supporting this code change is an outgrowth of the original research supporting unvented attic assemblies started in 1995 under the Department of Energy’s Building America Program. The same technical team and the same technical rigor that supported the original code changes for unvented attics in the early 2000s is the basis for this proposed code change.

- Current code language is limited to climate zones 1, 2 and 3 for air-permeable insulation based on research and historic experience over the past decade. Air-impermeable insulation approaches and rigid insulation approaches installed above the roof deck are currently code allowed in all climate zones.

- Vapor diffusion ports/vents allow moisture in the attic to be removed by diffusion rather than by air change. This allows the attic assembly to remain airtight while providing a path for moving the moisture to the outside via vapor diffusion. Airtight attics also provide an energy-efficiency benefit.

- When equipped with vapor diffusion ports, unvented attics can be insulated with other insulation materials, such as fiberglass batts, blown cellulose, and blown fiberglass, rather than polyurethane spray foam and rigid board insulation.

- Adding new unvented attic options to existing options provides additional benefits. In regions where high wildfire occurrence, elimination of eave vents and air sealing the upper attic vents at ridges significantly decreases entry paths for embers that could start a house fire. In hurricane zones, eliminating roof vents reduces the entry way for rainwater during storms.

The next section of this Code Compliance Brief lists applicable code requirements and details helpful for Plan Review. The Field Inspection section that follows provides details regarding the inspection of unvented attics and unvented enclosed rafter assemblies. Refer to the last section of this brief for resources on technical validation, best practices, and measure guidelines.

These lists and provisions provided below in each section are intended to target the main code sections and provisions. There may be other references, code sections, standards, testing methods, etc., that affect the technology or other assemblies or functions of the building.
Air-impermeable insulation is defined in the 2015 IRC as an insulation having an air permanence equal to or less than 0.02 L/s-m² at 75 Pa pressure differential as tested in accordance with ASTM E 2178 or E 283.

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Plan Review:

This section, provides current code sections and details in the 2015 IRC and IECC, and the language (underscored, struck-through, and highlighted in red) from code change proposals that were approved for the 2018 IRC.

2015 IRC, Section R104 Duties and Powers of the Building Official

Section R104.1, General. The building official has authority to render interpretations of this code and to adopt policies and procedures in order to clarify the application of its provisions. Such interpretations, policies and procedures shall be in conformance with the intent and purpose of this code.

2015 IECC/IRC, Section R102.1/R104.11, Alternative Materials, Design and Method of Construction and Equipment. The provisions of this code are not intended to prevent the installation of any material or prohibit any design or method of construction not specifically prescribed in the 2015 IECC/IRC, provided that any such alternative has been approved. The building official is permitted to approve an alternative material, design, or method of construction where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and the material, method, or work offered is for the purpose intended, not less than the equivalent of that prescribed in the code. Compliance with specific performance-based provisions of the International Codes is an alternative to the specific requirements of this code.

2015 IRC, Section R104.11.1, Tests. Whenever there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternative materials or methods, the building official has authority to require tests as evidence of compliance to be made at no expense to the jurisdiction. Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the building official shall approve the testing procedures. Tests shall be performed by an approved agency. Reports of such tests shall be retained by the building official for the period required for retention of public records.

Construction Documentation. Review the construction documents for details describing roof ventilation, attic insulation, installation, air sealing, and construction techniques. (Bullet items underscored are based on the 2018 ICC code proposals.)

2015 IECC/IRC, Section R103.3/R106.3, Examination of Documents, the code official/building official must examine or cause to be examined construction documents for code compliance.

2015 IECC/IRC, Section R103.2/N1101.5, Information on Construction Documents. Construction documents should be of sufficient clarity to indicate the location, nature, extent of the work proposed, and show of sufficient detail pertinent data features. (Bullet items below that are underscored and highlighted in red are based on the new provisions that will be published in the 2018 IRC. Construction documents should include:

- Roof assembly details.
  - **Vapor diffusion port(s)/vent(s) design and location.**
- Moisture barrier material used for the **vapor diffusion port(s)/vent(s).**
- Insulation materials and their R-values.
- Details indicating how the insulation is to be applied.
  - Where preformed insulation board is used as the **air-impermeable insulation layer,** confirm that the construction documents specify air sealing at the perimeter of each individual sheet interior surface to form a continuous layer.
- Air sealing details (joints, seams, penetrations).
- Confirm that the continuous air barrier is specified.
- Details of roof ventilation and moisture control.
  - **Design specifications of air supplied to the conditioned attic.**

2015 IRC, Section R202, Definitions

**Vapor Diffusion Port.** A passageway for conveying water vapor from an unvented attic to the outside atmosphere.
Section R806.5. Unvented attic and unvented enclosed rafter assemblies. Unvented attics and unvented enclosed roof framing assemblies created by ceilings that are applied directly to the underside of the roof framing members and structural roof sheathing applied directly to the top of the roof framing members/rafters, shall be permitted where all the following conditions are met:

1. The unvented attic space is completely within the building thermal envelope. [3]
2. No interior Class I vapor retarders are installed on the ceiling side (attic floor) of the unvented attic assembly or on the ceiling side of the unvented enclosed roof framing assembly.
3. Where wood shingles or shakes are used, a minimum ¼-inch (6.4 mm) vented airspace separate the shingles or shakes and the roofing underlayment above the structural sheathing.
4. In climate zones 5, 6, 7, and 8, any air-impermeable insulation shall be a Class II vapor retarder, or shall have a Class II vapor retarder coating or covering in direct contact with the underside of the insulation.
5. Insulation shall be located in accordance with the following with comply with either 5.1 or 5.2, and additionally 5.3:

5.1. Item 5.1.1, 5.1.2, 5.1.3, or 5.1.4 shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.

5.1.1. Where only air-impermeable insulation is provided, it shall be applied in direct contact with the underside of the structural roof sheathing.

5.1.2. Where air-permeable insulation is provided inside the building thermal envelope, it shall be installed in accordance with Section 5.1. In addition to the air-permeable insulation installed directly below the structural sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing in accordance with the R-values in Table R806.5 for condensation control.

5.1.3. Where both air-impermeable and air-permeable insulation are provided, the air-impermeable insulation shall be applied in direct contact with the underside of the structural roof sheathing in accordance with Item 5.1.1 and shall be in accordance with the R-values in Table R806.5 for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.

5.1.4. Alternatively, sufficient rigid board or sheet insulation shall be installed directly above the structural roof sheathing to maintain the monthly average temperature of the underside of the structural roof sheathing above 45°F (7°C). For calculation purposes, an interior air temperature of 68°F (20°C) is assumed, and the exterior air temperature is assumed to be the monthly average outside air temperature of the three coldest months.

5.1.5. In climate zones 1, 2, and 3 air shall be supplied at a flow rate ≥50 CFM (23.6 L/s) per 1000 ft² of ceiling. The air shall be supplied from ductwork providing supply air to the occupiable space when the conditioning system is operating. Alternatively one of the following shall occur:

1. Air shall be supplied to the attic by a fan blowing air from the occupiable space into the attic.
2. Transfer air from the occupiable space shall be provided by a fan exhausting attic air to the outside.
3. Mechanical dehumidification shall be provided to the unvented attic air space.

5.2. In climate zones 1, 2, and 3 when air-permeable insulation is installed in unvented attics, it shall meet the following requirements:

1) An approved vapor diffusion port shall be installed not more than 12 inches (305 mm) from the highest point of the roof, measured vertically from the highest point of the roof to the lower edge of the port.
2) The port area shall be ≥1:600 of the ceiling area. Where there are multiple ports in the attic, the sum of the port areas shall be greater than or equal to the area requirement.
3) The vapor permeable membrane in the vapor diffusion port shall have a vapor permeance rating of ≥20 perms when tested in accordance with Procedure A of ASTM E96.

Confirm the vapor permeable membrane product specifications have been tested and rated accordingly.
4) The vapor diffusion port shall serve as an air barrier between the attic and the exterior of the building.
5) The vapor diffusion port shall protect the attic against the entrance of rain and snow.
6) Framing members and blocking shall not block the free flow of water vapor to the port. Not less than a 2-inch (50-mm) space shall be provided between any blocking and the roof sheathing. Air-permeable insulation shall be permitted within that space.
7) The roof slope shall be 3:12 (vertical/horizontal).

8) Where only air-permeable insulation is used, it shall be installed directly below the structural roof sheathing.

9) **Air-impermeable insulation**, if any, shall be directly above or below the structural roof sheathing and is not required to meet the R-value in Table 806.5. When directly below the structural roof sheathing, there shall be no space between the air-impermeable and air-permeable insulation.

10) The air shall be supplied at a flow rate ≥50 CFM (23.6 L/s) per 1000 ft² of ceiling. The air shall be supplied from ductwork providing supply air to the occupiable space when the conditioning system is operating. Alternatively, the air shall be supplied by a supply fan when the conditioning system is operating.

5.3. Where preformed insulation board is used as the air-impermeable insulation layer, it shall be sealed at the perimeter of each individual sheet interior surface to form a continuous layer.

Excerpt from **2015 IRC, Table R806.5 Insulation for Condensation Control**

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Minimum rigid Board on Air-Impermeable Insulation R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 3, 4</td>
<td>R-5</td>
</tr>
</tbody>
</table>

**2015 IECC/IRC, Section R402.1.2/N1102.1.2, Insulation Criteria.** The building thermal envelope must meet the requirements of Table R402.1.2/N1102.1.2, based on the climate zone specified in Chapter 3 and the building assemblies associated with the unvented attic assemblies that are considered part of the building thermal envelope.

**2015 IECC/IRC, Section R402.1.3/N1102.1.3 or 2012 IECC/IRC, Section R402.1.2/N1102.1.2, R-Value Computation.** Insulation material used in layers, such as framing cavity insulation, or continuous insulation should be summed to compute the corresponding component R-value. Computed R-values should not include an R-value for other building materials or air films.

Excerpt from the **Insulation and Fenestration Requirements by Component Tables**

**2015 IECC/IRC, Table R402.1.2/N1101.1.2 or 2012 IECC/IRC, Table R402.1.1/N1102.1.1** (R-values are the same for both versions of IECC/IRC.)

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Ceiling R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>2, 3</td>
<td>38</td>
</tr>
</tbody>
</table>

This means if air-impermeable insulation is installed in direct contact with the underside of the structural roof sheathing, a minimum of R-5 rigid foam board is required, and the sum of air-permeable insulation directly below the air-impermeable insulation must meet a minimum R-value of R-25 in climate zone 1 and R-33 in climate zones 2 and 3.

**2015 IECC/IRC, Section R402.1.4/N1102.1.4 or 2012 IECC/IRC Section R402.1.3/N1102.1.3, U-Factor Alternative.** An assembly with a U-factor equal to or less than that specified in tables should be permitted as an alternative to the R-value in the Insulation and Fenestration Requirements by Component Tables of the IECC/IRC.

Excerpt from the **Equivalent U-Factor Tables**

**2015 IECC/IRC, Table R402.1.4/N1102.1.4 or 2012 IECC/IRC, Table R402.1.3/N1102.1.3.** (U-factors are the same for both versions of the codes.)

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Ceiling U-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.035</td>
</tr>
<tr>
<td>2, 3</td>
<td>0.030</td>
</tr>
</tbody>
</table>

**Air Sealing/Air Leakage Control**

**2015 IECC/IRC, Section R402.4./N1102.4, Air Leakage.** The building thermal envelope should be constructed to limit air leakage.

- **Section R402.4.1/N1102.4.1, Building Thermal Envelope.** The sealing methods between dissimilar materials should allow for differential expansion and contraction.
- **Section R402.4.1.1/N1102.4.1.1, Installation.** The components listed in the Air Barrier and Insulation Installation Table[4] should be installed in accordance with the manufacturer’s instructions and the criteria listed as the applicable method of construction. Below are the General Requirements and components from the table that are applicable to sealing and insulating unvented attics.

**Air Barrier and Insulation Installation Table R402.4.1.1/N1102.4.1.1**
Continuous air barrier – Confirm that construction documents specify a continuous air barrier for the building components associated with the insulation. Air-permeable insulation should not be used as a sealing material.

2015 IECC/IRC, Section R501.1.1/N1107.1.1, Alterations - General. Alterations to an existing building or portion thereof should comply with Section R502/N1110, R503/N1109 or R504/N1110. Unaltered portions of the existing building are not required to comply.

Section R503.1/N1109.1, General. Alterations to any building or structure should comply with the requirements of the code for new construction. Alterations should be such that the existing building or structure is no less conforming to the provisions of this code than the existing building or structure was prior to the alteration. Alterations should not create an unsafe or hazardous condition or overload existing building systems. Alterations should be such that the existing building or structure uses no more energy than the existing building or structure prior to the alteration.

Section R503.2/N1103.2, Change in space conditioning. Any non-conditioned or low-energy space that is altered to become conditioned space should be required to be in full compliance with this code. (This means not only the altered assembly is brought into compliance but the entire space or building also would need to be brought into compliance.)

Section R503.1.1/N1109.1.1, Building Envelope. Building envelope assemblies that are part of the alteration must comply with Sections R402.1.2/N1102.1.2 (Insulation and Fenestration Table) or R402.1.4/N1102.1.4 (U-Factor Alternative), and Sections R402.2.1/N1102.2.1 through R402.2.12/N1102.2.12, R402.3/1/N1102.3.1, R402.3.2/N1102.3.2, R402.4.3/N1102.4.3 and R402.4.4/N1102.4.4.

Exception: The following alterations need not comply with the requirements for new construction provided the energy use of the building is not increased:

- Existing ceiling cavities exposed during construction, provided that the cavities are filled with insulation
- Construction where the existing roof cavity is not exposed
- Roof recover
- Roofs without insulation in the cavity and where the sheathing or insulation is exposed during reroofing should be insulated either above or below the sheathing.

[3] The term “building thermal envelope” is defined as 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.

[4] Table R402.4.1.1 of the IECC and Table N1102.4.1.1 of the IRC.

[5] The term “continuous air barrier” is defined as a combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.

Field Inspection:

This section provides details for inspecting to the specific provisions for construction of unvented attics or enclosed unvented rafter assemblies, roof insulation, ventilation, and moisture controls where one or more specific types of inspection called for by the IECC or IRC may be necessary to confirm compliance. Framing and rough-in would be the typical type of inspection performed. (Bullet items underscored and highlighted in red are based on the new provisions for the 2018 IRC.)

Per the 2015 IECC, Section R104 Inspections, construction or work for which a permit is required is subject to inspection. Construction or work is to remain accessible and exposed for inspection purposes until approved. Required inspections include footings and the foundation, framing and rough-in work, plumbing rough-in, mechanical rough-in, and final inspection.

Per the 2015 IRC, Section R109 Inspections, for onsite construction, from time to time the building official, upon notification from the permit holder or his agent, can make or cause to be made any necessary inspections. Further details are provided for inspections regarding the foundation, plumbing, mechanical, gas and electrical, floodplain, frame and masonry, and the final inspection. Any additional inspections are at the discretion of the building official.

Inspections should provide verification with the following items if specified and approved on the construction documents and per manufacturer specifications and installation:

- Verify that joints, seams, holes, and penetrations are caulked, gasketed, weather-stripped, or otherwise sealed (assemblies part of the building thermal envelope).
- Ensure that the appearance of the insulation, as appropriate, in the field matches what is on the approved construction documents.
• If the R-value or U-factor approach for compliance was used in the documentation, ensure that the insulation installed meets the minimum R-value(s) specified for the assembly per climate zone based upon the approved construction documents.

• Confirm that the continuous air barrier is properly installed.

• Where preformed insulation board is used as the air-impermeable insulation layer, confirm that it is sealed at the perimeter of each individual sheet interior surface to form a continuous layer.

• Confirm that the vapor diffusion port(s) are installed per the approved construction documents.

• Confirm that the moisture barrier material used for the vapor diffusion port(s) is the same material specified on the approved construction documents.

• Confirm that the air supplied to the conditioned attic meets the approved construction documents.

**Technical Validation(s):**

This section provides additional related information and references to materials that are applicable to the provision.

  Author(s): ICC
  Organization(s): ICC
  Publication Date: May 2014
  This code establishes a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems, and service water heating systems in homes and commercial businesses.

• **2015 IRC—International Residential Code for One- and Two-Family Dwellings** [3]
  Author(s): ICC
  Organization(s): ICC
  Publication Date: May 2014
  This code for residential buildings creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy, and electrical provisions for one- and two-family residences.

• **Understanding Attic Ventilation** [4]
  Author(s): J. Lstiburek
  Organization(s): Building Science Corporation (BSC)
  Publication Date: October 2006
  This report provides guidance about whether to construct a vented or unvented attic based on hygro-thermal zone.


**Related BASC Guides:**

• Unvented Attic Insulation, [https://basc.pnnl.gov/resource-guides/unvented-attic-insulation][8]

• Ceilings, [https://basc.pnnl.gov/resource-guides/ceilings#quicktabs-guides=6][9]

• Spray Foam Applied to Existing Ceilings, [https://basc.pnnl.gov/resource-guides/spray-foam-insulation-applied-exis...][10]

• Above-Deck Rigid Foam Insulation for Existing Roofs, [https://basc.pnnl.gov/resource-guides/above-deck-rigid-foam-insulation-e...][11]

• Below-Deck Spray Foam Insulation for Existing Roofs, [https://basc.pnnl.gov/resource-guides/below-deck-spray-foam-insulation-e...][12].