**Scope**

Install insulation along the underside of the roof deck of an unvented attic rather than on the ceiling deck of a vented attic for either of two reasons: to provide an unvented, conditioned space for locating HVAC equipment in the attic, and/or to provide a continuous thermal barrier for designs that have complex coffered ceiling planes and/or numerous penetrations for lights, speakers, vents, soffits, etc., which make it difficult to achieve an airtight ceiling plane.

Install insulation to levels that meet or exceed code or energy-efficiency program requirements.

See the [Compliance Tab](#) for related codes and standards requirements, and criteria to meet national programs such as DOE's Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
Description

Unvented roof assemblies, such as conditioned attics and unvented cathedral ceilings, are created by eliminating ventilation openings and moving the thermal (insulation), moisture, and air control boundaries to the plane of the roof deck. These unvented cathedralized attic assemblies (also known as a “compact” or “hot roof” assemblies) can be used to overcome two major problems associated with vented attics:

1. Locating ducts/air handling units in the attic space can be a cause of major air leaks of conditioned air to unconditioned space (and thus forced infiltration/exfiltration), and heat/loss gain through the ductwork.

2. Designs with complex coffered ceiling planes, and numerous penetrations by lights, speakers, vents, etc., make it practically difficult to achieve the airtightness required just below the insulation layer.

In cases where mechanical systems are located in attics, moving the air control layer and thermal control layer to the roof deck has particularly large advantages compared to sealing and insulating attic ceilings and ductwork. In addition it might not be desirable (in hurricane or wildfire areas) or practical (in retrofit) to add roof vents at soffit locations. Accordingly, there may not be any practical alternative to moving the air control layer and thermal control layer to the roof deck (Figure 1). When this design choice is made, spray foams have advantages over alternative insulation methods because of the ability of spray foams to effectively air seal complex assemblies. Spray foam can provide the thermal and vapor control layers in both new and retrofit construction.

![Figure 1](image-url)  
*Note: Colored shading depicts the building’s thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.*

All unvented attic and cathedral ceiling designs must provide for either a very high degree of airtightness or avoidance of condensation due to warming of cold surfaces. To meet durability goals in most applications, the airtightness must be provided by a continuous membrane—preferably adhered to the top surface of the structural roof deck and under rigid insulation that provides condensation control. In designs where the air tightness is provided between framing elements, spray foam has been found to be a practical solution. However, all wood-to-wood joints in the framing must still be sealed.

The key to creating an unvented roof assembly is to keep the roof deck – the principle condensing surface in roof assemblies – sufficiently warm throughout the year such that condensation will not occur, or to prevent interior moisture laden air from accessing the roof deck. This is done by using what is referred to as “air-impermeable insulation,” such as rigid foam board or spray foam.

Two acceptable methods for insulating an unvented attic assembly in all climates are as follows:

1. Air-impermeable insulation (typically spray foam) installed to the underside of the roof sheathing. For more information on this technique see the guide Spray Foam Under Roof Sheathing.

2. Air-impermeable insulation (typically rigid foam insulating sheathing) installed over the roof sheathing. For more information on this technique see the guide Above Deck Rigid Foam Insulation for Existing Roofs.

In both assemblies, air-permeable insulation (such as batt or loose fill) can be used to increase overall insulation value. This is
by no means a requirement; however, it is typically the most economical way to achieve target (or code minimum) R-values. Alternately, “air-impermeable insulation” alone could be used for the entire insulation thickness, assuming that all climate-specific code requirements are met (see Climate section).

The minimum required thickness of the “air-impermeable insulation” is stated in Table R806.5 - Insulation for Condensation Control of the 2012 IRC, which provides prescriptive requirements for minimum rigid board or air-impermeable insulation R-values based on climate zone, in order to manage the condensation potential in the assembly. See the Climate tab for details.

When designing a highly insulated roof (high-R value roof), it is important, especially in cold climates, to note the ratio of vapor-impermeable to vapor-permeable R-values. For cold climates, the air-impermeable insulation is maintained at 50% or more of the total R-value of the roof system. This is for condensation control. When building high-R-value roof systems, BSC recommends that this ratio be maintained or exceeded. If an R-80 unvented cathedralized attic is to be constructed in a cold climate, it is recommended that a minimum of R-40 (50%) be air-impermeable insulation installed and layered according to Section R806.5 of the 2012 IRC. (see the case study “Application of Spray Foam Insulation Under Plywood and OSB Roof Sheathing” at the More Info tab.)

Below are general instructions for the two unvented attic designs.

**Air-Impermeable Insulation Installed to the Underside of the Roof Sheathing in a Cathedral Ceiling**

Figure 2 shows an unvented cathedralized attic design with air-impermeable expanding spray foam insulation installed at the underside of the roof deck.

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**How to Install Spray Foam under the Roof Deck in a Cathedral Ceiling**

* It is recommended that the spray foam insulation is installed by a licensed professional applicator.

1. Refer to the current state and local building codes for the minimum R-value of air-impermeable insulation required for the roof assemblies in your climate.
2. Inspect the roof assembly to ensure it has proper drainage protection above the roof deck.
3. Measure the moisture content of the wood prior to applying spray foam insulation to ensure it has dried to the levels recommended by the spray foam manufacturer.
4. Ensure the weather conditions and temperatures for installing the insulation are as recommended by the spray foam manufacturer.
5. Clean the surfaces of the roof sheathing and structural members so they are clear of any debris or dust to ensure proper adhesion of the spray foam.
6. Cover any mechanical and electrical equipment and wiring prior to applying the insulation.
7. Provide proper ventilation in the work area during application.
8. It is recommended to hire a licensed professional applicator for the spray foam installation.
9. Visually inspect the insulation installation.
10. Refer to the current state and local building codes for definition and requirements for the ignition and thermal barrier as well as vapor diffusion retarder requirements.
11. Install cavity insulation.

**Air-Impermeable Insulation Installed Over the Roof Sheathing with a Cathedral Ceiling**

Figure 3 shows an unvented cathedralized attic design with air-impermeable insulating sheathing installed over the roof deck. A structural nail base would typically be required over the rigid foam for a roof cladding such as asphalt shingles. To meet durability goals in most applications, the airtightness must be provided by a continuous membrane—preferably adhered to the top surface of the structural roof deck and under rigid insulation that provides condensation control.

![Figure 3. Unvented cathedralized attic detail, with air-impermeable insulating sheathing installed over the roof deck.](image)

**How to Install Insulating Sheathing over the Roof Deck with a Cathedral Ceiling**

1. Refer to the current state and local building codes for the minimum R-value of air-impermeable insulation required for the roof assemblies in your climate.
2. Install a weather-resistant, air-impermeable roofing underlayment (i.e., fully adhered membrane), properly lapped, and ensure it is integrated with the wall weather resistive barrier (e.g., house wrap).
3. Inspect roof deck weather resistive barrier for any leaks or any inconsistencies.
4. Install insulating sheathing in multiple layers with joints offset in both directions and taped.
5. Install OSB/plywood over the insulating sheathing to serve as a nailbase.
6. Install proper roofing underlayment and roof cladding according to manufacturer’s instruction.
7. Install cavity insulation.

**How to Install Ducts in an Unvented Attic**

When installing HVAC equipment in an insulated conditioned attic, good HVAC design principles still apply:

1. Design a compact, duct layout with short, straight ducts runs. Seal and test ductwork for air leakage.
2. Install a balanced ventilation system such as a heat recovery ventilator or central fan-integrated ventilation with a fresh air intake and timered exhaust. (For more information, see Whole-Building Delivered Ventilation.)
3. Do not install low-efficiency heating systems that draw their combustion air from the attic. Instead install direct-vent sealed-combustion furnaces or heat pumps. (For more information, see Combustion Furnaces, Traditional Split Heat Pumps)
Ensuring Success

Regular inspections should be conducted between major points in construction to check on the integrity of the water, air, thermal and vapor control layers of the roof. Monitor the moisture content of the roof sheathing, when possible, during the construction process. Take measurements before the installation of the air-impermeable insulation to ensure that the roof deck is dry enough to be covered. This is especially true for spray foam installed to the underside of the roof deck. Ensure correct ambient temperature for spray foam application and ensure that framing and underside of roof decking has been swept clean of dust and debris before installing spray foam.

When installing HVAC equipment in an insulated, conditioned attic, design a compact duct layout with short, straight ducts runs. Seal and test ductwork for air leakage. Install a balanced ventilation system. Install high-efficiency direct-vent sealed-combustion furnaces or heat pumps.
Climate

The International Energy Conservation Code (IECC) requires minimum levels of air-impermeable insulation for each climate zone. The climate zones are shown on the map below, which is taken from Figure C301.1 of the 2012 IECC. See the Compliance tab for climate-specific requirements.

IECC climate zone map

All of Alaska is in Zone 7 except for the following boroughs in Zone 8:
Bethel, Northwest Arctic, Dillingham, Southeast Fairbanks, Fairbanks N. Star, Wade Hampton, Nome, Yukon-Koyukuk, North Slope

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands
Training

Right and Wrong Images

Display Image: Coble2-Closed Cell Foam-HE-Jan 2010.png

Display Image: Coble3-Attic-HE-Jan 2010.png
UNVENTED ATTIC
2x10 RAFTER - INSULATION ABOVE ROOF DECK AND IN RAFTER CAVITY

CAD FILE: TE61_Unvented_Attic_Insulation BSC.dwg
PDF: TE61_Unvented_Attic_Insulation-2x10 Rafter - Insulation Above Roof Deck and In Rafter Cavity CAD.pdf
UNVENTED ATTIC
2x10 RAFTER - INSULATION BELOW ROOF DECK IN RAFTER CAVITY

CAD FILE: TE61-Unvented_Attic_Insulation BSC.dwg
PDF: TE61-Unvented_Attic_Insulation-2x10 Rafter - Insulation Below Roof Deck In Rafter Cavity CAD.pdf

UNVENTED ATTIC
2x12 RAFTER - INSULATION ABOVE ROOF DECK AND IN RAFTER CAVITY

CAD FILE: TE61-Unvented_Attic_Insulation BSC.dwg
PDF: TE61-Unvented_Attic_Insulation-2x12 Rafter - Insulation Above Roof Deck and In Rafter Cavity CAD.pdf
UNVENTED ATTIC
2x12 RAFTER - INSULATION BELOW ROOF DECK IN RAFTER CAVITY

CAD FILE:  TE61_Unvented_Attic_Insulation BSC.dwg
PDF:  TE61_Unvented_Attic_Insulation-2x12 Rafter - Insulation Below Roof Deck In Rafter Cavity CAD.pdf
Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

ENERGY STAR Certified Homes, Version 3/3.1 (Rev. 09)

ENERGY STAR Certified Homes requires that ceiling, wall, floor, and slab insulation levels meet or exceed those specified in the 2009 International Energy Conservation Code (IECC) with some alternatives and exceptions, and achieve Grade 1 installation per RESNET Standards (see 2009 and 2012 IECC Code Level Insulation – ENERGY STAR Requirements and Insulation Installation (RESNET Grade 1). If the state or local residential building energy code requires higher insulation levels than those specified in the 2009 IECC, you must meet or exceed the locally mandated requirements. Visit the U.S. DOE Building Energy Codes Program to see what code has been adopted in each state.

DOE Zero Energy Ready Home (Revision 07)

Exhibit 1 Mandatory Requirements.
Exhibit 1, Item 1) Certified under the ENERGY STAR Qualified Homes Program or the ENERGY STAR Multifamily New Construction Program.
Exhibit 2, Item 2) Ceiling, wall, floor, and slab insulation shall meet or exceed 2015 IECC levels and achieve Grade 1 installation, per RESNET standards. See the guide 2015 IECC Code Level Insulation – DOE Zero Energy Ready Home Requirements for more details.
Exhibit 1, Item 3) Duct distribution systems located within the home’s thermal and air barrier boundary or an optimized location to achieve comparable performance.

Footnote 14) Exceptions and alternative compliance paths to locating 100% of forced-air ducts in home’s thermal and air barrier boundary are:

1. Up to 10’ of total duct length is permitted to be outside of the home’s thermal and air barrier boundary.
2. Ducts are located in an unvented attic, regardless of whether this space is conditioned with a supply register.
3. Ducts are located in a vented attic with all of the following characteristics: ?Note that in either of these designs the HVAC equipment must still be located within the home’s thermal and air barrier boundary.
   1. In Moist climates (Zones 1A, 2A, 3A, 4A, 5A, 6A and 7A per 2015 IECC Figure R301.1) and Marine climates (all “C” Zones per 2015 IECC Figure R301.1), minimum R-8 duct insulation with an additional minimum 1.5” of closed-cell spray foam insulation encapsulating the ducts; duct leakage to outdoors ? 3 CFM25 per 100 ft² of conditioned floor area (in addition to meeting total duct leakage requirements from Section 4.1 of the ENERGY STAR HVAC Rater checklist); and ductwork buried under at least 2” of blown-in insulation.
   2. In Dry climates (all “B” Zones per 2015 IECC Figure R301.1), minimum R-8 duct insulation; duct leakage to outdoors ? 3 CFM25 per 100 ft² of conditioned floor area (in addition to meeting total duct leakage requirements from Section 4.1 of the ENERGY STAR HVAC Rater checklist); and ductwork buried under at least 3.5” of blown-in insulation.
4. Systems which meet the criteria for “Ducts Located in Conditioned Space” as defined by the 2018 IECC Section R403.3.7
5. Jump ducts which do not directly deliver conditioned air from the HVAC unit may be located in attics if all joints, including boot-to-drywall, are fully air sealed with mastic or foam, and the jump duct is fully buried under the attic insulation.
6. Ducts are located within an unvented crawl space.
7. Ducts are located in a basement which is within the home’s thermal boundary.
8. Ductless HVAC system is used.

2009 - 2018 IECC and IRC Minimum Insulation Requirements: The minimum insulation requirements for ceilings, walls, floors, and foundations in new homes, as listed in the 2009, 2012, 2015, and 2018 IECC and IRC, can be found in this table.


Total ceiling insulation values are shown by climate zone in Table R402.1.1 (R402.1.2 in 2015 and 2018 IECC); excerpts are shown in Table 1 below.

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Ceiling R-Value</th>
<th>Wood Frame Wall R-Value</th>
<th>Mass Wall R-Value* (2009 IRC: 3)</th>
<th>Floor R-Value</th>
<th>Basement Wall R-Value</th>
<th>Slab R-Value &amp; Depth</th>
<th>Crawl Space Wall R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30 30</td>
<td>30 30</td>
<td>13 13</td>
<td>3/4 3/4</td>
<td>13 13</td>
<td>0 0</td>
<td>0 0 0 0</td>
</tr>
<tr>
<td>2</td>
<td>30 38</td>
<td>30 38</td>
<td>13 13</td>
<td>4/6 4/6</td>
<td>13 13</td>
<td>0 0</td>
<td>0 0 0 0</td>
</tr>
<tr>
<td>3</td>
<td>30 38</td>
<td>30 38</td>
<td>13 13</td>
<td>5/8 8/13</td>
<td>19 19</td>
<td>5/13 5/13</td>
<td>0 0</td>
</tr>
<tr>
<td>4 except Marine</td>
<td>38 49</td>
<td>13 20 or 13+5</td>
<td>5/10 8/1</td>
<td>19 19</td>
<td>10/13 10/13</td>
<td>10, 2 ft</td>
<td>10/13 10/13</td>
</tr>
<tr>
<td>5 and Marine 4</td>
<td>38 49</td>
<td>20 or 13+5</td>
<td>13/17 13/17</td>
<td>30 30^4</td>
<td>10/13 10/13</td>
<td>15/19 10/13</td>
<td>10/13 10/13</td>
</tr>
<tr>
<td>6</td>
<td>49 49</td>
<td>20 or 13+5</td>
<td>15/19 15/20</td>
<td>30 30^6</td>
<td>15/19 10/13</td>
<td>10/13 10/13</td>
<td>10/13 10/13</td>
</tr>
<tr>
<td>7 and 8</td>
<td>49 49</td>
<td>21 20 or 13+10</td>
<td>19/21 19/21</td>
<td>38 38^4</td>
<td>15/19 10/13</td>
<td>10/13 10/13</td>
<td>10/13 10/13</td>
</tr>
</tbody>
</table>

For Sf: 1 foot = 304.8 mm.

*a The IRC code requirement differs from the IECC code requirement, as noted.

- Table adapted from Table R402.1.1 in the 2009 and 2012 IECC and Table R402.1.2 in the 2015 and 2018 IECC (Table N1102.1 in 2009 IRC, Table 1102.1 in 2012 IRC, and Table N1102.1.2 in 2015 and 2018 IRC).
- 2012, 2015, and 2018 IECC: R-values are minimums. When insulation is installed in a cavity which is less than the label or design thickness of the insulation, the installed R-value of the insulation shall not be less than the R-value specified in the table.
- 2009 IECC: R-values are minimums. R-19 batts compressed into a nominal 2x6 framing cavity such that the R-value is reduced by R-1 or more shall be marked with the compressed R-value in addition to the full thickness R-value.
- Refers to fenestration requirements not shown on this excerpted table.
- 2009-2018 IECC: “10/13” means R-10 continuous insulation (called “insulated sheathing” in 2009 IECC) on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall. “15/19” means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. Alternatively, compliance with “15/19” shall be R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the home.
- 2009 IRC Only: The first R-value applies to continuous insulation, the second to framing cavity insulation; either insulation meets the requirement.
- 2018 IECC: R-5 insulation shall be provided under the full slab area of a heated slab in addition to the required slab edge insulation R-value for slabs, as indicated in the table. The slab edge insulation for heated slabs shall not be required to extend below the slab.
- 2009, 2012, and 2015 IECC: R-5 shall be added to the required slab edge R-values for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less in Climate Zones 1 through 3 for heated slabs.
- Retrofit: 2009, 2012, 2015, and 2018 IECC. Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for Section R101.4.3 (Section R501.1.1 in 2015 and 2018 IECC).
additional requirements and exceptions.)


The 2009 and 2012 IRC Section R202 defines vapor retarders class information. A vapor retarder is defined as “a measure of the ability of a material or assembly to limit the amount of moisture that passes through that material or assembly.” Vapor retarder classes are defined by the IRC using the desiccant method with Procedure A of ASTM E96. These classes are:

Class I: 0.1 perm or less
Class II: 0.1 perm to 1.0 perm
Class III: 1 perm to 10 perms

The IRC has had information on unvented attics for several editions. The 2012 IRC Section R806 contains the following requirements, with slight modifications from the 2009 edition, with the most notable addition being identification of vapor retarders by class in R806.5 items 2 and 4. In IRC 2018, see Section R806.5 for additional information about the vapor permeability of the insulation used.

R806.5 Unvented attic and unvented enclosed rafter assemblies. Unvented attic assemblies and unvented enclosed rafter assemblies are permitted if all the following conditions are met:

1. The unvented attic space is completely contained within the building thermal envelope.
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 rafter assembly.
3. Where wood shingles or shakes are used, a minimum ¼” (6mm) vented air space separates 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. [Note, the 2012 IRC says “or be coated with a Class III vapor retarder.” “Class III” is a typo that has been corrected to Class II in the 2015 I codes (BSC personal communication 6-27-14).]
5. Meet one of the following conditions, depending on the air permeability of the insulation directly under the structural roof sheathing.
   I. Air-impermeable insulation only. Insulation shall be applied in direct contact with the underside of the structural roof sheathing.
   II. Air-permeable insulation only. 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 as specified in Table R806.5 for condensation control.
   III. Air-impermeable and air-permeable insulation. The air-impermeable insulation shall be applied in direct contact with the underside of the structural roof sheathing as specified in Table R806.5 for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.
   IV. 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.

Wording in the 2018 IRC differs for #5:

5. Insulation shall comply with Item 5.3 and either item 5.1 or 5.2:
   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 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.
   5.2. In Climate Zones 1, 2 and 3, air-permeable insulation installed in unvented attics shall meet the following requirements:
5.2.1 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.

5.2.2 The port area shall be greater than or equal to 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.

5.2.3 The vapor-permeable membrane in the vapor diffusion port shall have a vapor permeance rating of greater than or equal to 20 perms when tested in accordance with Procedure A of ASTM E96.

5.2.4 The vapor diffusion port shall serve as an air barrier between the attic and the exterior of the building.

5.2.5 The vapor diffusion port shall protect the attic against the entrance of rain and snow.

5.2.6 Framing members and blocking shall not block the free flow of water vapor to the port. Not less than a 2-inch (51 mm) space shall be provided between any blocking and the roof sheathing. Air-permeable insulation shall be permitted within that space.

5.2.7 The roof slope shall be greater than or equal to 3:12 (vertical/horizontal).

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

5.2.9 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. Where directly below the structural roof sheathing, there shall be no space between the air-impermeable insulation and air-permeable insulation.

5.2.10 The air shall be supplied at a flow rate greater than or equal to 50 cfm (23.6 L/s) per 1,000 square feet (93 m²) 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 condition system is operating.

5.3 Where pre-formed 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.

The IRC for Climate Zones 1, 2, 3, or 4 requires that a Class I vapor control layer not be installed on the interior side of the assembly. This is to prevent inward-driven moisture from being trapped in the wall assembly. Installing a low-permeance vapor control layer on the interior in a cooling dominated climate can quickly deteriorate the assembly.

Table N1102.1.1 of the 2012 IRC (N1102.1.2 in 2015 and 2018 IRC) lists the thermal insulation requirements for each assembly. A summary of the requirements combining Table R806.5 and Table N1102.1.1 from the 2009, 12, 15, and 18 IRC editions is shown in Table 2. This table shows the total amount of insulation required in unvented attics and unvented enclosed roof framing assemblies and the minimum amount of that insulation that should be impermeable, based on climate zone.

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Minimum Amount of Insulation that is Air-Impermeable or Rigid Board</th>
<th>Unvented Attic Total Required Installed R-Valuea,b</th>
</tr>
</thead>
<tbody>
<tr>
<td>2B and 3B</td>
<td>0 (none required)</td>
<td>30, 30</td>
</tr>
<tr>
<td>tile roof only</td>
<td></td>
<td>2009 IRC</td>
</tr>
<tr>
<td>1, 2A, 2B, 3A, 3B, 3C</td>
<td>R-5</td>
<td>30, 38</td>
</tr>
<tr>
<td>4C</td>
<td>R-10</td>
<td>30, 38</td>
</tr>
<tr>
<td>4A, 4B</td>
<td>R-15</td>
<td>38, 49</td>
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<tr>
<td>5</td>
<td>R-20</td>
<td>38, 49</td>
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<tr>
<td>6</td>
<td>R-25</td>
<td>49, 49</td>
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<tr>
<td>7</td>
<td>R-30</td>
<td>49, 49</td>
</tr>
<tr>
<td>8</td>
<td>R-35</td>
<td>49, 49</td>
</tr>
</tbody>
</table>

a. Contributes to bud does not supersede the requirements in Section N1102.
b. Alternatively, sufficient continuous 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.
In cold climates it is important to note the ratio of vapor impermeable to vapor permeable R-values. For cold climates, the air impermeable insulation is maintained at 50% or more of the total R-value of the roof system. This is for condensation control. When building high-R value roof systems Building Science Corporation recommends that this ratio be maintained or exceeded. If an R-80 cathedral ceiling or cathedralized attic is to be constructed in a cold climate, it is recommended that a minimum of R-40 (50%) be air impermeable insulation installed and layered according to Section R806.5 of the 2012 IRC.


Section N1101.3 (Section N1107.1.1 in 2015 and 2018 IRC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

Appendix J regulates the repair, renovation, alteration, and reconstruction of existing buildings and is intended to encourage their continued safe use.

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 port/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.

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Table 2. Air-Impermeable Insulation for Condensation Control in Unvented Attics, per IRC Table 806.5.
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.


[2] 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.

**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.
When 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 73:12 (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, 2A, 2B, 3A, 3B, 3C</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></td>
<td></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**[5] – 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/N1108, 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.

- **2015 IECC—International Energy Conservation Code**
  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**
  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**
  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.

- **BSI-088: Venting Vapor**, Joseph Lstiburek, Building Science Corporation, July 2015,  


Related BASC Guides:

• Unvented Attic Insulation, https://basc.pnnl.gov/resource-guides/unvented-attic-insulation
• Ceilings, https://basc.pnnl.gov/resource-guides/ceilings#quicktabs-guides=6
• Spray Foam Applied to Existing Ceilings, https://basc.pnnl.gov/resource-guides/spray-foam-insulation-applied-exis...
• Above-Deck Rigid Foam Insulation for Existing Roofs, https://basc.pnnl.gov/resource-guides/above-deck-rigid-foam-insulation-e...
• Below-Deck Spray Foam Insulation for Existing Roofs, https://basc.pnnl.gov/resource-guides/below-deck-spray-foam-insulation-e...
More Info.

Access to some references may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

Case Studies

1. **Technology Solutions Case Study: Application of Spray Foam Insulation Under Plywood and OSB Roof Sheathing**
   - **Author(s):** BSC
   - **Organization(s):** BSC
   - **Publication Date:** November, 2013
     - Case study describing research about spray foam roof insulation and moisture management.

References and Resources*

1. **Avoiding Wet Roofs - Part I**
   - **Author(s):** Yost
   - **Organization(s):** Journal of Light Construction
   - **Publication Date:** June, 2018
     - Article describing the building science implications of insulating vented or unvented attics.

2. **Avoiding Wet Roofs - Part II**
   - **Author(s):** Yost
   - **Organization(s):** Journal of Light Construction
   - **Publication Date:** July, 2018
     - Article describing the research into insulating vented versus unvented attics.

3. **Cool Hand Luke Meets Attics**
   - **Author(s):** Lstiburek
   - **Organization(s):** BSC
   - **Publication Date:** July, 2015
     - Article describing the difference between conditioned or unvented attics and unconditioned or vented attics.

4. **Field Performance of Unvented Cathedralized (UC) Attics in the USA**
   - **Author(s):** Rudd
   - **Organization(s):** Building Science Corporation
   - **Publication Date:** January, 2005
     - Journal article reporting on field experience of unvented cathedralized (UC) attics in several environments in the United States.

5. **How to Build an Insulated Cathedral Ceiling**
   - **Author(s):** Holladay
   - **Organization(s):** Green Building Advisor
   - **Publication Date:** November, 2011
     - Information sheet presenting the correct methods for building an insulated cathedral ceiling.

6. **Hybrid Assemblies**
   - **Author(s):** Lstiburek
   - **Organization(s):** BSC
   - **Publication Date:** July, 2015
     - Article describing issues with condensation in unvented attics insulated with open-cell spray foam.

7. **IRC FAQ: Conditioned Attics**
   - **Author(s):** Building Science Corporation
   - **Organization(s):** Building Science Corporation
   - **Publication Date:** May, 2009
     - Report discussing how to create livable space in the attic that meets IRC code requirements by either creating a ventilated roof assembly, or and unvented attic assembly.

8. 
Sealed Attics?
(830KB)
Author(s): Coble
Organization(s): Home Energy Magazine
Publication Date: January, 2010
Article describing how insulating and air sealing unfinished attic spaces can lead to reduced energy bills in some homes.

9. Understanding Attic Ventilation
Author(s): Lstiburek
Organization(s): Building Science Corporation
Publication Date: October, 2006
Report providing guidance about whether to construct a vented or unvented attic based on hygro-thermal zone.

10. Unvented Roof Assemblies for All Climates
Author(s): Schumacher
Organization(s): Building Science Corporation
Publication Date: April, 2007
Report reviewing unvented roof assemblies, such as conditioned attics and unvented cathedral ceilings that are becoming common in North American construction.

11. Unvented Roof Summary
Author(s): Kohta
Organization(s): Building Science Corporation
Publication Date: January, 2003
Document summarizing the various papers on unvented conditioned cathedralized attics found on BSC’s website.

12. Unvented-Cathedralized Attics: Where We’ve Been and Where We’re Going
Author(s): Rudd, Lstiburek, Ueno
Organization(s): Building Science Corporation
Publication Date: August, 2000
Report focusing on the performance and durability of unvented-cathedralized attics in hot-humid climates with both tile and asphalt shingle roofing.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.

Contributors to this Guide
The following authors and organizations contributed to the content in this Guide.

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