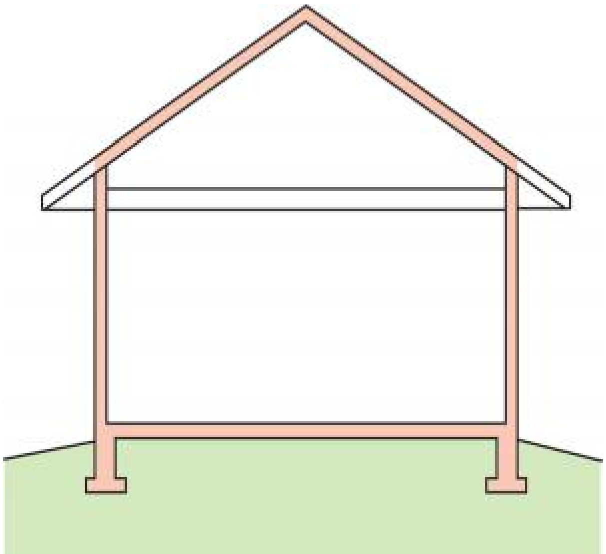
Unvented Attic Insulation

Last Updated: 06/23/2014

Scope



Install insulation at the roof deck of an unvented 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 with complex coffered ceiling planes and numerous penetrations by lights, speakers, vents, etc., which make it practically difficult to achieve the airtightness required just below the insulation layer.

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

The insulation components for unvented attic assembly can be successfully designed and installed, based on recommendations from this Guide and the requirements of the **2012 International Residential Code (IRC)** Section R806.5 "Unvented attic and unvented enclosed rafter assemblies." The intent of Section R806.5 is to require unvented attic assembly designs that keep the roof deck – the principle condensing surface in roof assemblies – sufficiently warm throughout the year, 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 above the roof deck or spray foam on the underside of the roof deck.

DOE Zero Energy Ready Home Notes

The U.S. Department of Energy **Zero Energy Ready Home National Program Requirements** specify as a mandatory requirement (Exhibit 1, #2.2) that, for all labeled homes, whether prescriptive or performance path, ceiling, wall, floor, and slab insulation shall meet or exceed 2012 IECC levels. See the guide **2012 IECC Code Level Insulation – DOE Zero Energy Ready Home Requirements** for more details.

The DOE Zero Energy Ready Home National Program Requirements also specify as a mandatory requirement (Exhibit 1, #3) that ducts are located within the home's thermal and air barrier boundary. See the Compliance tab for exceptions and alternative compliance options.

ENERGY STAR Certified Homes Notes

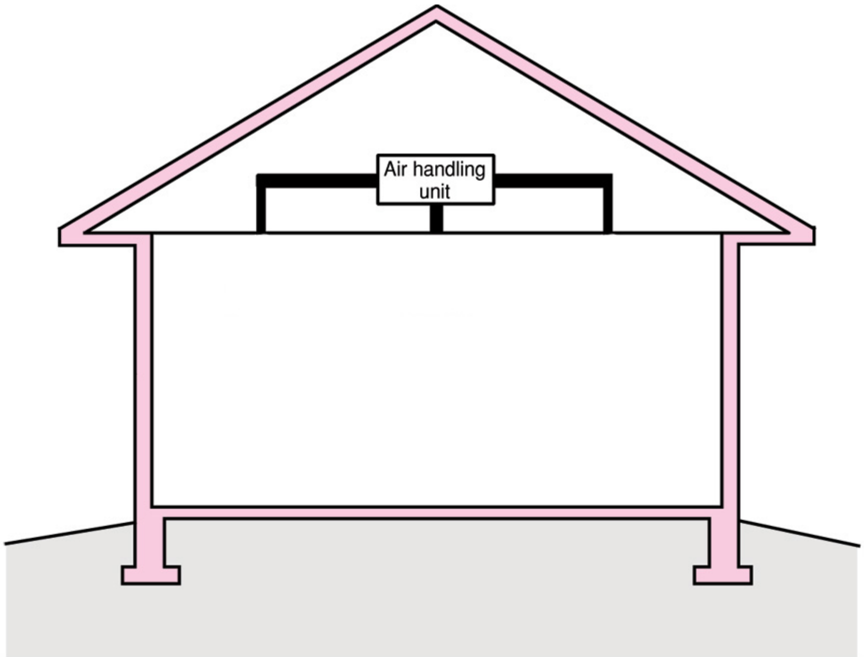
ENERGY STAR Certified Homes requires that ceiling, wall, floor, and slab insulation levels meet or exceed those specified in the 2009 International Energy Conservation Code (IECC) with some alternatives and exceptions. See the guide TE 2.1.1 ENERGY STAR 2009 IECC Code Level Insulation for more details.

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” assembly or “hot roof”) 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 underside of 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 underside of the roof deck. When this design choice is made, spray foams have advantages over alternative methods because of the ability of spray foams to effectively air seal complex assemblies. As well, spray foam can provide the thermal and vapor control layers in both new and retrofit construction.



Note: Colored shading depicts the building’s thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

Figure 1. Ductwork in an unvented attic.

All unvented attic and cathedral ceiling designs must provide for either a very high degree of airtightness or avoidance of condensation by warming sensitive 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.

There are two acceptable methods to designing an unvented attic assembly:

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) is 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

Figure 1 shows an unvented cathedralized attic design with air-impermeable expanding spray foam insulation installed at the underside of the roof deck.

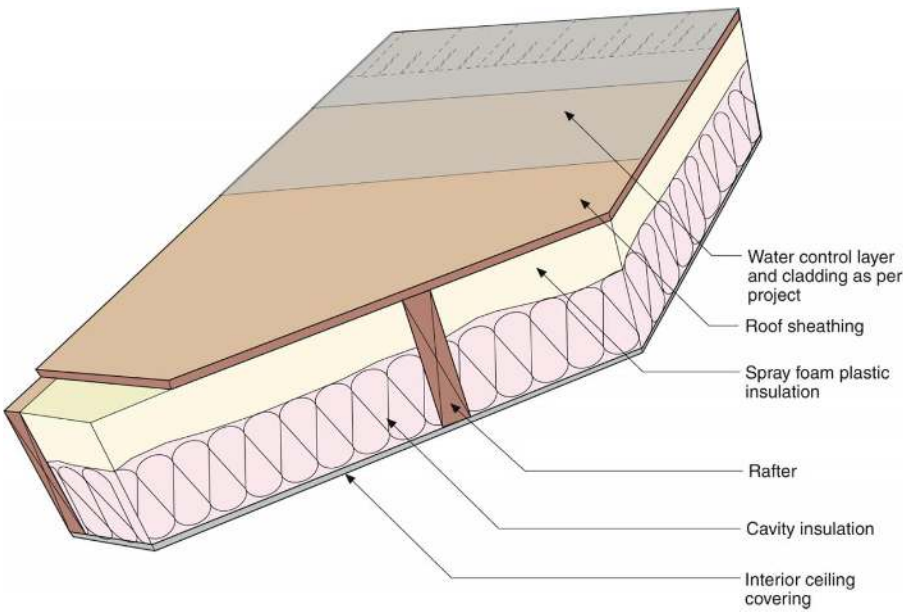


Figure 2. Unvented cathedralized attic detail, with air-impermeable spray foam insulation installed to the underside of the roof deck.

How to Install Spray Foam under the Roof Deck

* 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

Figure 2 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.

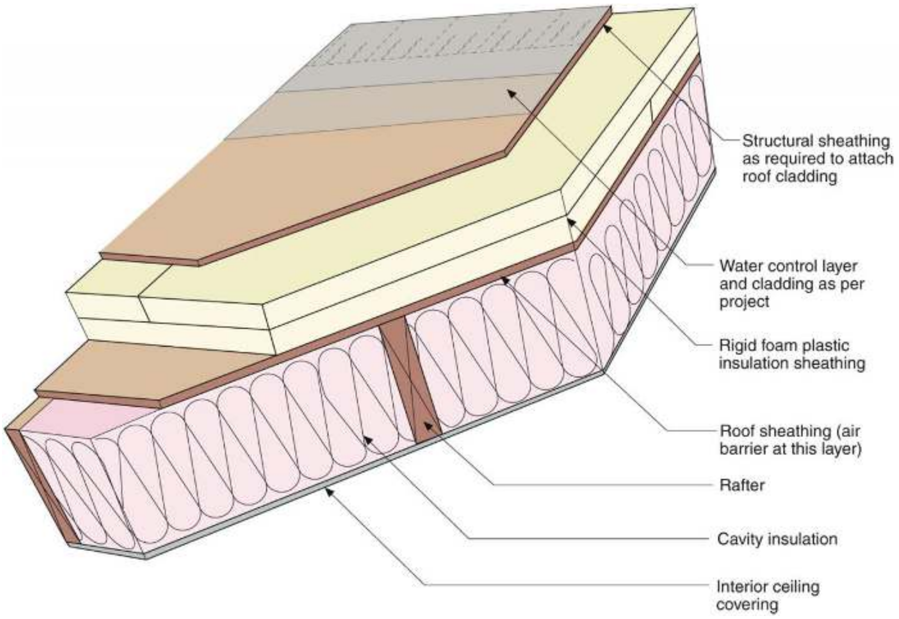


Figure 3. Unvented cathedralized attic detail, with air-impermeable insulating sheathing installed over the roof deck.

How to Install Insulating Sheathing over the Roof Deck

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 resistive, 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**)

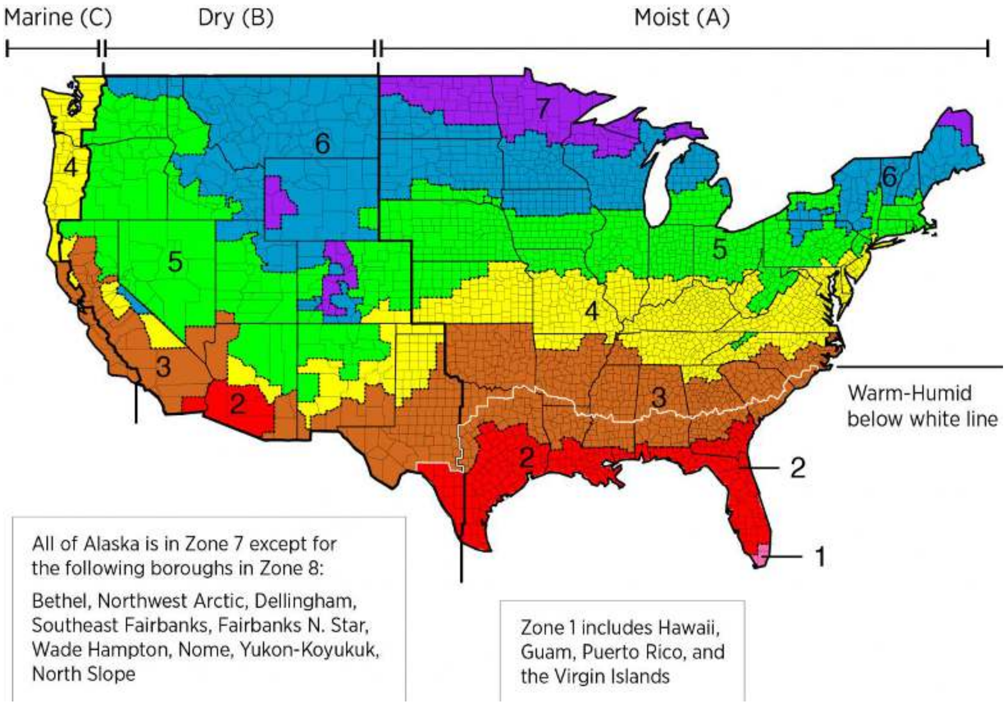
Ensuring Success

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.



IECC climate zone map

Table N1102.1.1 of the 2012 IRC lists the thermal insulation requirements for attics in each IECC climate zone. A summary of the requirements combining Table R806.5 and Table N1102.1.1 is shown in the table below. Please refer to the Compliance tab for the full 2012 code language.

2012 IRC Table R806.5 and Table N1102.1.1 R-Values

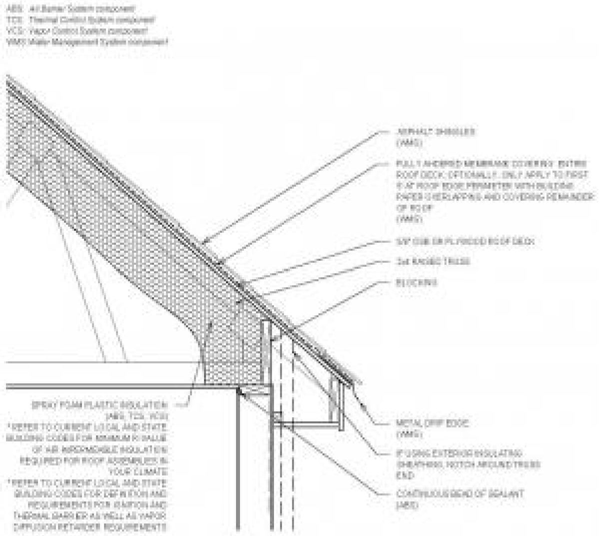
Climate Zone	Minimum Rigid Board or Air-Impermeable Insulation R-Value	Total Required Installed R-Value
2B and 3B tile roof only	0 (none required)	30
1, 2A, 2B, 3A, 3B, 3C	R-5	30
4C	R-10	30
4A, 4B	R-15	38
5	R-20	38
6	R-25	49
7	R-30	49
8	R-35	49

Training

Right and Wrong Images

None Available

CAD



CAD FILE: [TE61_Unvented_Attic_Insulation BSC.dwg]
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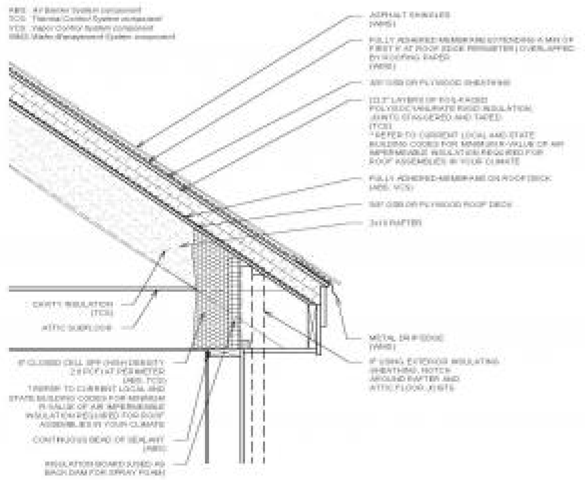
Courtesy Of: [BSC]



UNVENTED ATTIC
2x10 RAFTER - INSULATION ABOVE ROOF DECK AND IN RAFTER CAVITY

CAD FILE: [TE61_Unvented_Attic_Insulation BSC.dwg]
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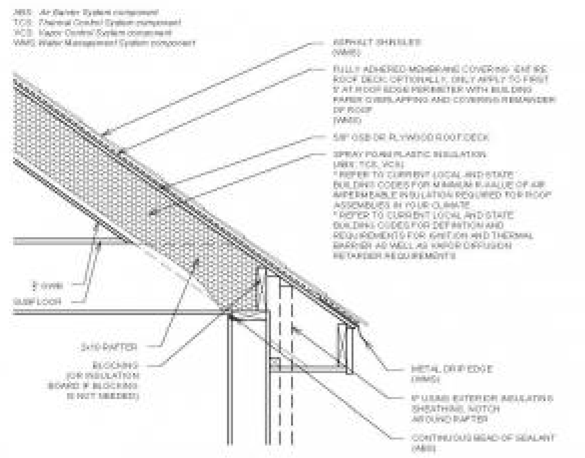

UNVENTED ATTIC
2x10 RAFTER - INSULATION BELOW ROOF DECK IN RAFTER CAVITY

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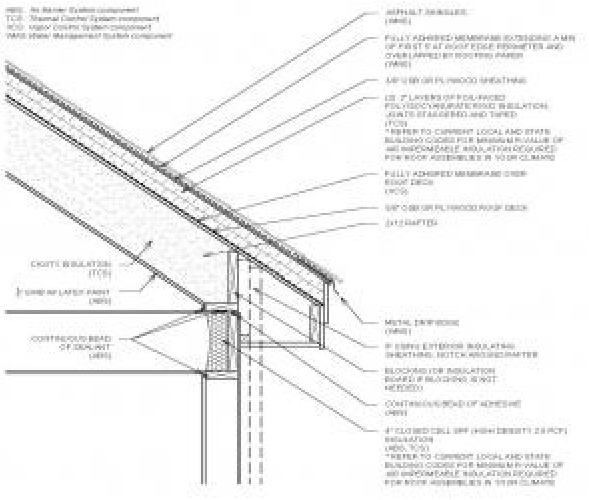

UNVENTED ATTIC
2x12 RAFTER - INSULATION ABOVE ROOF DECK AND IN RAFTER CAVITY

CAD FILE: TE61_Unvented_Attic_Insulation BSC.dwg
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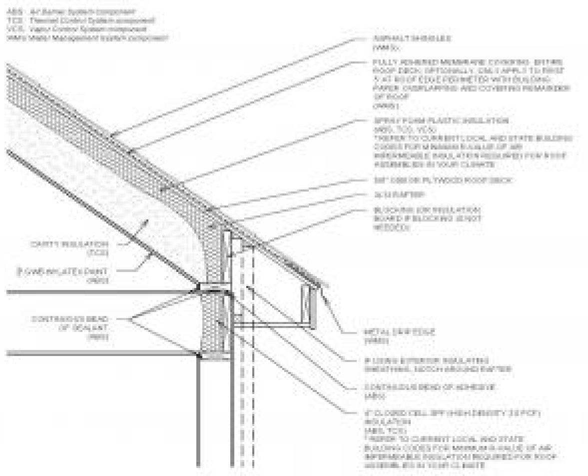
Courtesy Of: BSC



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
Courtesy Of: BSC

Compliance

2009 and 2012 IRC

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.

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.

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 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 and 2012 IRC editions is shown in Table 1.

2012 IRC Table R806.5 and Table N1102.1.1 R-Values

Climate Zone	Minimum Rigid Board or Air-Impermeable Insulation R-Value	Total Required Installed R-Value 2009 IRC	2012 IRC
2B and 3B tile roof only	0 (none required)	30	30
1, 2A, 2B, 3A, 3B, 3C	R-5	30	38
4C	R-10	30	38
4A, 4B	R-15	38	49
5	R-20	38	49
6	R-25	49	49
7	R-30	49	49
8	R-35	49	49

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.

2009 and 2012 IECC

Total ceiling insulation values are shown by climate zone in Table R402.1.1; excerpts are shown in Table 1 below.

Ceiling Insulation R Values, Excerpted from Table 402.1.1 of the 2009 and 2012 IECC

Climate Zone	2009 IECC	2012 IECC
1	30	30
2	30	38
3	30	38
4 Except Marine	38	49
5 and Marine	38	49
6	49	49
7 and 8	49	49

2009 IECC Sec 402.2.1 and 2012 IECC Sec. R 402.2.1 note that where the table specifies R-38, R-30 will be sufficient if the full height of R-30 extends uncompressed over the wall top plate at the eaves. Similarly R-38 will be sufficient where R-49 is required if a full thickness of R-38 extends over the top plates. Sec 402.2.2 notes that in parts of ceiling where the attic design does not allow space to install more than R-30 of insulation, R-30 will suffice; however, this exception is limited to no more than 500 square feet of total ceiling area.

DOE Zero Energy Ready Home

The U.S. Department of Energy Zero Energy Ready Home National Program Requirements specify as a mandatory requirement (Exhibit 1, #2.2) that, for all labeled homes, whether prescriptive or performance path, ceiling, wall, floor, and slab insulation shall meet or exceed 2012 IECC levels. See the guide **2012 IECC Code Level Insulation – DOE Zero Energy Ready Home Requirements** for more details.

The DOE Zero Energy Ready Home National Program Requirements also specify as a mandatory requirement (Exhibit 1, #3) that ducts are located within the home's thermal and air barrier boundary.

(16) Exceptions and alternative compliance paths to locating 100% of forced-air ducts in home's thermal and air barrier boundary are:

a. Up to 10' of total duct length is permitted to be outside of the home's thermal and air barrier boundary.

b. Ducts are located in an unvented attic, regardless of whether this space is conditioned with a supply register.

c. Ducts are located in a vented attic with all of the following characteristics:

   i. In Moist climates (Zones 1A, 2A, 3A, 4A, 5A, 6A and 7A per 2012 IECC Figure R301.1) and Marine climates (all "C" Zones per 2012 IECC Figure R301.1), minimum R-8 duct insulation with an additional minimum 1.5" of closed-cell spray foam insulation encapsulating the ducts; total duct leakage ? 3 CFM25 per 100 ft2 of conditioned floor area; and ductwork buried under at least 2" of blown-in insulation.

   ii. In Dry climates (all "B" Zones per 2012 IECC Figure R301.1), minimum R-8 duct insulation; total duct leakage ? 3 CFM25 per 100 ft2 of conditioned floor area; and ductwork buried under at least 3.5" of blown-in insulation. Note that in either of these designs the HVAC equipment must still be located within the home's thermal and air barrier boundary.

d. 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.
e. Ducts are located within an unvented crawl space.\
f. Ducts are located in a basement which is within the home's thermal boundary
g. Ductless HVAC system is used.

ENERGY STAR Certified Homes

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) and achieve Grade 1 installation per RESNET Standards (see **2009 IECC Code Level Insulation – ENERGY STAR Requirements** and **Insulation Installation (RESNET Grade 1)**.

See the **interactive map** of 2009 IECC insulation levels by climate zone.

See the guide **2009 IECC Code Level Insulation - ENERGY STAR Requirements** for more details.

More Info.

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. **2012 IECC—International Energy Conservation Code**
   Author(s): ICC
   Organization(s): ICC
   Publication Date: January, 2012
   Code establishing 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.

2. **2012 IRC—International Residential Code for One and Two Family Dwellings**
   Author(s): ICC
   Organization(s): ICC
   Publication Date: January, 2012
   Code for residential buildings that 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.

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

4. **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.

5. **IRC FAQ: Conditioned Attics**
   Author(s): BSC
   Organization(s): BSC
   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.

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

7. **Unvented Roof Assemblies for All Climates**
   Author(s): Schumacher
   Organization(s): BSC
   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.

8.

[Unvented Roof Summary]
Author(s): Kohta
Organization(s): BSC
Publication Date: January, 2003
Document summarizing the various papers on unvented conditioned cathedralized attics found on BSC's website.

9. **Unvented-Cathedralized Attics: Where We've Been and Where We're Going**
Author(s): Rudd, Lstiburek, Ueno
Organization(s): BSC
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.

Source URL (retrieved on *2014-10-21 10:01*): https://basc.pnnl.gov/resource-guides/unvented-attic-insulation