Conditioned or Unconditioned Attic

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Scope

Determine whether to locate the thermal boundary at the roof line or at the ceiling plane of a home. This decision will be based on several factors, including

- climate
- desire for additional living and storage space
- building design and configuration
- location of HVAC.
Description

Where to locate the thermal boundary is an important design consideration when designing the roof-attic-ceiling assemblies in new construction. The thermal boundary consists of the thermal barrier (insulation) and the air barrier (for example, caulked sheathing or mudded and taped drywall). These two layers should both be continuous around the building envelope (walls, ceiling, floor) and they should be in continuous contact with each other.

In a roof-attic assembly, the builder has two choices: the thermal boundary can be at the ceiling plane, leaving the attic space above uninsulated and vented, or the thermal boundary can be located at the roof line, creating a sealed, insulated, conditioned or semi-conditioned attic space. When the thermal boundary is at the ceiling level, the ceiling drywall serves as the air barrier; any gaps around penetrations (for wiring, flues, ducts, etc.) are carefully air sealed. The thermal barrier consists of the insulation (typically blown fiberglass or cellulose, sometimes spray foam and batt), which is piled on top of the ceiling drywall. Vents are installed at the soffits and at or near the ridge, and baffles are installed at each soffit vent to provide a pathway for ventilation air and to keep insulation from blocking the soffit vents. When the thermal barrier is located at the roof line, it can be either above or below the roof decking.

See Figures 1 through 3 for examples of thermal boundary locations for vented and unvented attics for three attic designs: flat ceiling/gable roof, low-sloped shed roof, and 1-and ½-story home.

Figure 1. The thermal boundary for a gable roof can be located at either a) the flat ceiling with a vented attic or b) the roof line for an unvented attic. (Source: BSC)

Figure 2. A low-sloped shed roof with the thermal boundary located at either a) the flat ceiling with a vented attic or b) the roof line for an unvented attic. (Source: BSC)
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 an air-impermeable insulation such as rigid foam board or spray foam. Rigid foam insulating sheathing is installed on top of the roof sheathing. For more information on this technique, see the guide Above Deck Rigid Foam Insulation for Existing Roofs. Spray foam is installed on the underside of the roof sheathing. For more information on this technique, see the guide Spray Foam Under Roof Sheathing. Both methods require a very high degree of airtightness or avoidance of condensation due to warming of cold surfaces. For above-deck rigid foam, air tightness is achieved by installing a continuous membrane over the roof sheathing and under the rigid foam. This membrane could be a peel-and-stick or paint-on membrane or a carefully installed underlayment. For below-deck insulation, the spray foam will provide condensation control. However, all wood-to-wood joints in the framing must still be sealed. In both assemblies, air-permeable insulation (such as batt or loose fill) can be used to increase the overall insulation value. For the above-deck rigid foam option, the batt or blown insulation would go below the decking. The minimum required thickness of the “air-impermeable insulation” to manage condensation potential is stated in Table R806.5 - Insulation for Condensation Control of the 2012 IRC. For cold climates, the air-impermeable insulation should be maintained at 50% or more of the total R-value of the roof system for condensation control. For example, if an R-80 unvented cathedralized attic is to be constructed in a cold climate, a minimum of R-40 (50%) should be air-impermeable insulation installed and layered according to Section R806.5 of the 2012 IRC (Figure 4). See the IRC or the guide Unvented Attic Insulation for details.

Factors to consider when determining where to locate the thermal barrier in new construction include climate, desire for additional living and storage space, building design and configuration, and location of HVAC.

In hot, humid locations, coastal locations in hurricane regions, and in areas prone to wildfires, it may be advisable to not construct a vented attic because soffit vents can be an entry point for wind-blown rain and burning embers and, while the purpose of soffit

Figure 3. A 1- and ½-story home with a room located in the attic and the thermal boundary located at either a) the walls and ceiling of the attic room with small vented attic spaces or b) the roof line for an unvented attic. (Source: BSC)
vents is to help reduce moisture in the attic, in hot, humid locations the outside air is likely to be more humid than inside conditioned air.

Other reasons for constructing an unvented attic include the following. The builder (or homebuyer if the buyer has purchased prior to construction) may want the attic space to be conditioned for additional living or storage space. The home design may have a complex interior design that would require many transitions between flat ceilings, knee walls, trey ceilings, and/or vaulted ceilings. In such cases, where numerous transitions make it difficult to achieve a continuous thermal barrier at the ceiling, it may be simpler and thus less expensive to insulate at the roof line. A design decision to have a central ducted heating and cooling system with ducts and air handler located in the attic is another good reason to insulate and air seal at the roof line, which will provide a conditioned or semi-conditioned space for the HVAC equipment. This can improve HVAC performance and longevity as the equipment does not have to work against the much greater temperature differentials of a vented attic.

For installation guidance for vented and unvented attics in new and existing homes, see these Building America Solution Center guides. For more information, search “attics” or “roofs” in the Solution Center:

- Unvented Attic Insulation
- Attic Eave Minimum Insulation
- Attic Knee Walls
- Insulation Below Attic Platforms
- Blown Insulation for Existing Vented Atticc
- Batt Insulation for Existing Vented Attics
- Spray Foam Insulation Applied to Existing Attic Ceilings
- Below Deck Spray Foam Insulation for Existing Roofs
- Application of Spray Foam Insulation Under Plywood and OSB Roof Sheathing
- Above Deck Rigid Foam Insulation for Existing Roofs
Ensuring Success
Climate

There are climate-specific criteria for attic insulation requirements and impermeable insulation requirements for unvented attics. See the Compliance tab for specific criteria.
Training

Right and Wrong Images
None Available
CAD
None Available
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.

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.

2009 IECC

Section 402 Building Thermal Envelope. Table 402.1.1 indicates the prescriptive requirements for building enclosure components.

Section 402.2.1 Ceilings with attic spaces. This section indicates that the prescriptive requirement for R-38 ceiling insulations is deemed to be met by R-30 insulation when the R-30 insulation extends over the wall top plate at eaves and when the insulation is at full loft and uncompressed over the wall top plate at eaves. Similarly, R-38 insulation is recognized to satisfy the requirement for R-49 insulation when R-38 insulation extends over the wall top plate at eaves and when the insulation is at full loft and uncompressed over the wall top plate at eaves.

Section 402.2.2 Ceilings without attic spaces. Where the prescriptive requirements would require more than R-30 insulation but the roof/ceiling configuration cannot accommodate the insulation level indicated by the prescriptive requirements, R-30 is the minimum insulation requirement. This reduced insulation requirement is limited to the lesser of 500 square feet or 20% of the total insulated ceiling area.

Section 402.3. Access hatches and doors. Doors or hatches separating conditioned spaces from unconditioned spaces (such as attics and crawl spaces) must be weather stripped and insulated to a level equivalent to that of surrounding assemblies. When loose fill insulation is used, insulation dams are required around attic hatches.

Section 402.4 Air Leakage. This section indicates that the building thermal envelope (as it is called in the IECC) must be sealed to limit infiltration and that it must be sealed in a manner that is durable allowing for differential expansion and contraction.

2012 IECC

Section R402 Building Thermal Envelope. Table R402.1.1 indicates the prescriptive requirements for building enclosure components.

Section R402.2.1 Ceilings with attic spaces. This section indicates that the prescriptive requirement for R-38 ceiling insulations is deemed to be met by R-30 insulation when the R-30 insulation extends over the wall top plate at eaves and when the insulation is at full loft and uncompressed over the wall top plate at eaves. Similarly, R-38 insulation is recognized to satisfy the requirement for R-49 insulation when R-38 insulation extends over the wall top plate at eaves and when the insulation is at full loft and uncompressed over the wall top plate at eaves.

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Section R402.2.3 Eave baffle. This section indicates the requirement for baffles to be installed next to eave and soffit vents for vented attics using air permeable insulations. The baffle can be any solid material, must extend to the top of the attic insulation, and must maintain an opening that is at least as large as the vent.

Note that baffles should also be used with vented cathedral assemblies.

Section R402.4 Access hatches and doors. Doors or hatches separating conditioned spaces from unconditioned spaces (such as attics and crawl spaces) must be weather stripped and insulated to a level equivalent to that of surrounding assemblies. When loose fill insulation is used, insulation dams are required around attic hatches.

Section R402.4 Air Leakage. This section indicates that the building thermal envelope (as it is called in the IECC) must be sealed to limit infiltration and that it must be sealed in a manner that is durable allowing for differential expansion and contraction.


Section R101.4.3 (Section R501.1.1 in 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 additional requirements and exceptions.)

2009 IRC

Appendix J, Section 501.6. Ventilation. The appendix is not attached to the requirements of the IRC unless it is specifically included by the adopting jurisdiction. This section of the appendix indicates that any space that is changed to be habitable or occupiable by alteration must be provided with ventilation in accordance with Section R303.

Section R806.3 Vent and insulation clearance. A vent space clearance of at least 1" must be maintained at the location of the vent and between insulation and roof sheathing. Note that this would not apply where an unvented roof assembly is used as
Section R806.4 Unvented attic assemblies. This section outlines the conditions for unvented attic/roof assemblies. Note that table R806.4 indicates the amount of insulation above the roof deck or air impermeable insulation below the roof deck required for condensation control assuming minimum required total insulation as indicated in Section N1102 Building Thermal Envelope. Higher R-value assemblies will require a proportionally larger amount of air impermeable insulation below the roof deck or insulation above the roof deck for condensation control.

Section R807.1 Attic access. An attic access is required where the ceiling or roof construction is combustible and where the attic area is more than 30 sf and the height between the ceiling framing and roof framing is more than 30”. Refer to specific language of this section for required dimensions of the access.

Section N1102 Building Thermal Envelope. Table N1102.1 indicates the prescriptive requirements for building enclosure components.

Section N1102.2.1 Ceilings with attic spaces. This section indicates that the prescriptive requirement for R-38 ceiling insulations is deemed to be met by R-30 insulation when the R-30 insulation extends over the wall top plate at eaves and when the insulation is at full loft and uncompressed over the wall top plate at eaves. Similarly, R-38 insulation is recognized to satisfy the requirement for R-49 insulation when R-38 insulation extends over the wall top plate at eaves and when the insulation is at full loft and uncompressed over the wall top plate at eaves.

Section N1102.2.2 Ceilings without attic spaces. Where the prescriptive requirements would require more than R-30 insulation but the roof/ceiling configuration cannot accommodate the insulation level indicated by the prescriptive requirements, R-30 is the minimum insulation requirement. This reduced insulation requirement is limited to the lesser of 500 square feet or 20% of the total insulated ceiling area.

Section N1102.2.3 Access hatches and doors. Doors or hatches separating conditioned spaces from unconditioned spaces (such as attics and crawl spaces) must be weather stripped and insulated to a level equivalent to that of surrounding assemblies. When loose fill insulation is used, insulation dams are required around attic hatches.

Section N1102.4 Air Leakage. This section indicates that the building thermal envelope (as it is called in the IRC) must be sealed to limit infiltration and that it must be sealed in a manner that is durable allowing for differential expansion and contraction.

2012 IRC

Appendix J, Section 501.6, Ventilation. The appendix is not attached to the requirements of the IRC unless it is specifically included by the adopting jurisdiction. This section of the appendix indicates that any space that is changed to be habitable or occupiable by alteration must be provided with ventilation in accordance with Section R303.

Section R806.3 Vent and insulation clearance. A vent space clearance of at least 1” must be maintained at the location of the vent and between insulation and roof sheathing.

Note that this would not apply where an unvented roof assembly is used as indicated in section R806.5.

Section R806.4 Installation and weather protection. This section indicates that ventilators for roofs are to be installed in accordance with manufacturer’s installation instructions and the requirements of Section R903.

Section R806.5 Unvented attic assemblies. This section outlines the conditions for unvented attic/roof assemblies. Note that table R806.5 indicates the amount of insulation above the roof deck or air impermeable insulation below the roof deck required for condensation control assuming minimum required total insulation as indicated in Section N1102 Building Thermal Envelope. Higher R-value assemblies will require a proportionally larger amount of air impermeable insulation below the roof deck or insulation above the roof deck for condensation control.

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Section N1102 Building Thermal Envelope. Table N1102.1.1 indicates the prescriptive requirements for building enclosure components.

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Section N1102.2.2 Ceilings without attic spaces. Where the prescriptive requirements would require more than R-30 insulation but the roof/ceiling configuration cannot accommodate the insulation level indicated by the prescriptive requirements, R-30 is the minimum insulation requirement. This reduced insulation requirement is limited to the lesser of 500 square feet or 20% of the total insulated ceiling area.

Section N1102.2.3 Eave baffle. This section indicates the requirement for baffles to be installed next to eave and soffit vents for vented attics using air permeable insulations. The baffle can be any solid material, must extend to the top of the attic insulation, and must maintain an opening that is at least as large as the vent.
Note that baffles should also be used with vented cathedral assemblies. Section N1102.2.4 Access hatches and doors. Doors or hatches separating conditioned spaces from unconditioned spaces (such as attics and crawl spaces) must be weather stripped and insulated to a level equivalent to that of surrounding assemblies. When loose fill insulation is used, insulation dams are required around attic hatches.

Section N1102.4 Air Leakage. This section indicates that the building thermal envelope (as it is called in the IRC) must be sealed to limit infiltration and that it must be sealed in a manner that is durable allowing for differential expansion and contraction.

**Retrofit:** [2009, 2012, 2015, and 2018 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.
Case Studies
None Available

References and Resources*

1. **2009 IECC - International Energy Conservation Code**
   
   **Author(s):** International Code Council
   
   **Organization(s):** ICC
   
   **Publication Date:** January, 2009
   
   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. **2009 IRC - International Residential Code for One and Two Family Dwellings**
   
   **Author(s):** International Code Council
   
   **Organization(s):** ICC
   
   **Publication Date:** January, 2009
   
   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.

   
   **Author(s):** International Code Council
   
   **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.

4. **2012 IRC - International Residential Code for One and Two Family Dwellings**
   
   **Author(s):** International Code Council
   
   **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.

5. **2015 IECC - International Energy Conservation Code**
   
   **Author(s):** International Code Council
   
   **Organization(s):** ICC
   
   **Publication Date:** May, 2014
   
   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.

6. **2015 IRC - International Residential Code for One and Two Family Dwellings**
   
   **Author(s):** International Code Council
   
   **Organization(s):** ICC
   
   **Publication Date:** May, 2014
   
   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.
2018 IECC - International Energy Conservation Code
Author(s): International Code Council
Organization(s): ICC
Publication Date: November, 2017
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.

8. 2018 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: August, 2017
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.

9. Attic Air Sealing Guide and Details
Author(s): Lstiburek
Organization(s): Building Science Corporation
Publication Date: February, 2010
Document providing background and approach for the prep work necessary prior to adding attic insulation - focusing on
combustion safety, ventilation for indoor air quality, and attic ventilation for durability.

10. Attic or Roof? An Evaluation of Two Advanced Weatherization Packages
Author(s): Neuhauser
Organization(s): Building Science Corporation, National Renewable Energy Laboratory
Publication Date: June, 2012
Report about a project that examines implementation of advanced retrofit measures in the context of a large-scale
weatherization program and the archetypal Chicago, Illinois, brick bungalow.

11. High-R Roofs Case Study Analysis
Author(s): Straube, Grin
Organization(s): Building Science Corporation
Publication Date: March, 2009
Report that considers a number of promising wall systems that can meet the requirement for better thermal control.

Author(s): Pettit, Neuhauser, Gates
Organization(s): Building Science Corporation
Publication Date: July, 2013
Guidebook providing useful examples of high performance retrofit techniques for the building enclosure of wood frame
residential construction in a cold and somewhat wet climate.

Author(s): Loomis, Pettit
Organization(s): Building Science Corporation
Publication Date: May, 2015
This Measure Guideline provides design and construction information for a deep energy enclosure retrofit solution of a flat
roof assembly.

Author(s): Lstiburek
Organization(s): Building Science Corporation
Publication Date: September, 2014
Report that provides information and specifications to anyone that is attempting to air seal existing attics.

15. 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.
Contributors to this Guide
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