Pennsylvania Housing Research Center

- The Pennsylvania Housing Research Center (PHRC) provides and facilitates education, training, innovation, research, and dissemination to the residential construction industry for the purpose of improving the quality and affordability of housing.
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Program Description

Cathedral ceiling assemblies or ceilings without attics are not new concepts in residential designs. However, with the increased need for energy efficiency and tighter tolerance for moisture and air infiltration, the dedicated design for these assemblies cannot be overlooked. In this session, learn about prescriptive designs for ceilings without attic spaces and break down some of the critical details that may help achieve an energy-efficient assembly.
Learning Objectives

• Understand what ceilings without attic spaces are per the definition in the 2018 IRC.
• Review 2018 IRC prescriptive designs for ceilings without attic spaces.
• Examine how the lack of attention to details can lead to increased risk in assemblies. Increased risk could include a reduced insulation rating or susceptibility to early decay of building materials.
• Review key details that can increase the longevity of ceilings without attic space assemblies, which can provide an energy-efficient assembly for the end user.

Why Are You Here?

• What are the attic R-values in Pennsylvania?
• Take a look at how these R-values can change depending on the assembly
• Explain Cathedral Ceiling Assemblies and Ceilings without Attics?
• Walk through the prescriptive requirements
• Prescriptive designs
  - Vented
  - Unvented

Agenda
UCC Energy Code Summary

Chapter 11

On our website:
phrc.psu.edu


Climate Zones in PA

Table N1102.1.2

Prescriptive Ceiling R-Value Insulation

• N1102.1.2
  - CZ 4, 5 & 6: R-49
• N1102.2.1 Ceilings with attic spaces
  - CZ 4, 5 & 6: Potential reduction to R-38
• N1102.2.2 Ceilings without attic spaces
  - CZ 4, 5 & 6: Potential reduction to R-30

N102.2 Specific Insulation Requirements

• In addition to the requirements of Section N1102.1, insulation shall meet the specific requirements of Sections N1102.2.1 through N1102.2.13.
  - N1102.2.1
  - N1102.2.2
  - N1102.2.3

N1102.2.1 Ceilings With Attic Spaces

• Where Section R1102.1.2 requires R-38 insulation in the ceiling, installing R-30 insulation over 100 percent of the ceiling area requiring insulation shall satisfy the requirement for R-38 insulation wherever the full height of uncompressed R-30 insulation extends over the wall top plate at the eaves. Where Section N1102.1.2 requires R-49 insulation in the ceiling, installing R-38 insulation over 100 percent of the ceiling area requiring insulation shall satisfy the requirement for R-49 insulation wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves.
What is an Attic?

• **2018 IRC Definition:**
  - The unfinished space between the ceiling assembly and the roof assembly.

• **2018 IRC Commentary also adds:**
  - An attic is the unfinished space between the ceiling joists of the top story and the roof rafters.

Vented Ceiling Assemblies

• **Vented**
  - R806.1 – Ventilation Required
  - R806.2 – Minimum Vent Area (See Brian’s Webinar - Attic Ventilation Understanding the Why)
  - R806.3 – Vent & Insulation Clearance

• **Unvented**
  - R806.5 – Unvented Attic & Unvented Enclosed Rafter Assemblies
R806.1 Ventilation Required

- Enclosed attics and enclosed rafter spaces formed where ceilings are applied directly to the underside of roof rafters shall have cross ventilation for each separate space by ventilating openings protected against the entrance of rain or snow.

R806.3 Vent and Insulation Clearance

- Where eave or cornice vents are installed, blocking, bridging and insulation shall not block the free flow of air. Not less than a 1-inch space shall be provided between the insulation and the roof sheathing and at the location of the vent.
N1102.2.3 – Eave Baffle

- For air-permeable insulations in vented attics, a baffle shall be installed adjacent to soffit and eave vents. Baffles shall maintain an opening equal or greater than the size of the vent. The baffle shall extend over the top of the attic insulation. The baffle shall be permitted to be any solid material.
Where Section R1102.1.2 requires R-38 insulation in the ceiling, installing R-30 insulation over 100 percent of the ceiling area requiring insulation shall satisfy the requirement for R-38 insulation wherever the full height of uncompressed R-30 insulation extends over the wall top plate at the eaves. Where Section N1102.1.2 requires R-49 insulation in the ceiling, installing R-38 insulation over 100 percent of the ceiling area requiring insulation shall satisfy the requirement for R-49 insulation wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves.

Compressed Insulation Values - NAIMA

Ceilings With Attic Space

• Where Section N1102.2.1 requires insulation R-values greater than R-30 in the ceiling and the design of the roof/ceiling assembly does not allow sufficient space for the required insulation, the minimum required insulation R-value for such roof/ceiling assemblies shall be R-30. Insulation shall extend over the top of the wall plate to the outer edge of such plate and shall not be compressed. This reduction of insulation from the requirements of Section N1102.1.2 shall be limited to 500 square feet or 20 percent of the total insulated ceiling area, whichever is less.
Cathedral Ceiling Assembly - Rafter

- 2x12 = 11.25"
- Eave baffle = 2.5"
- Insulation clearance = 8.75"

Compressed Insulation Values - NAIMA

Cathedral Ceiling Assembly - Rafter

- 2x12 = 11.25"
- Eave baffle = 1.5"
- Insulation clearance = 9.75"
- 9.5" R-30 Insulation
- Eave baffle specification matters!
Cathedral Ceiling Assembly – Rafter & 2x4 Below Rafter

• 2x12 = 11.25"
• 2x4 = 3.5"
• Eave baffle = 2.5"
• Insulation clearance = 12.25"
• R-38 insulation = 12"

Cathedral Ceiling Assembly – Rafter & 2x4 Above Rafter

• 2x12 = 11.25"
• Insulation clearance = 11.25"
• R-38 insulation = 12"
• R-38 compressed to 11.25" = R-37

Josh Salinger
Fine Homebuilding
https://www.youtube.com/watch?v=fA3hZOb0F7s
Unvented Ceiling Assemblies

Vented vs. Unvented

• Vented
  - R806.1 – Ventilation Required
  - R806.2 – Minimum Vent Area (See Brian’s Webinar – Attic Ventilation Understanding the Why)
  - R806.3 – Vent & Insulation Clearance

• Unvented
  - R806.5 – Unvented Attic & Unvented Enclosed Rafter Assemblies

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.
2. Interior Class I vapor retarders are not 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 1/4-inch vented airspace 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.
R806.5 Unvented Attic and Unvented Enclosed Rafter Assemblies – Cont.

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 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 roof 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-permeable insulation shall be in direct contact with the underside of the structural roof sheathing 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 at least 3.6 °C (6.5 °F) above the exterior air temperature. Where air-permeable insulation is used, it shall be installed directly below the structural roof sheathing.

5.2. The roof slope shall be greater than or equal to 3:12 (vertical/horizontal). Framing members and blocking shall not block the free flow of water vapor to the port. Not less than a 2 " (51 mm) airspace separates the shingles or shakes and the roofing underlayment above the structural sheathing. Where air-impermeable insulation is used, it shall be installed directly below the structural roof 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.

- 5.2.1. An approved vapor diffusion port shall be installed not more than 12 inches (305 mm) from the highest point of the roof and shall meet the following requirements:
  - 5.2.1.1. The roof slope shall be greater than or equal to 3:12 (vertical/horizontal) measured vertically from the highest point of the roof to the lower edge of the port.
  - 5.2.1.2. The vapor diffusion port shall serve as an air barrier between the attic and the exterior of the building.
  - 5.2.1.3. The vapor diffusion port shall protect the attic against the entrance of rain and snow.

5.2.2. Where air-impermeable insulation is installed directly below the structural roof sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing and is not required to meet the following requirements:

- 5.2.2.1. The port areas shall be greater than or equal to the area requirement.
- 5.2.2.2. The horizontal area of the port shall be greater than or equal to the area requirement.

5.2.3. Where air-impermeable insulation is installed directly below the structural roof 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.

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

5.2.4. 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 at least 3.6 °C (6.5 °F) above the exterior air temperature. Where air-permeable insulation is used, it shall be installed directly below the structural roof sheathing.

- 5.2.4.1. Where both air-impermeable and air-permeable insulation are provided, the air-permeable insulation shall be in direct contact with the underside of the structural roof sheathing 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.
- 5.2.4.2. 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 at least 3.6 °C (6.5 °F) above the exterior air temperature. Where air-impermeable insulation is used, it shall be installed directly below the structural roof sheathing.

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 " (51 mm) airspace separates the shingles or shakes and the roofing underlayment above the structural sheathing. Where air-impermeable insulation is used, it shall be 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.

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

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

5.2.9. Air-permeable insulation shall be provided between any blocking and the roof sheathing. Air-permeable insulation shall be applied in direct contact with the underside of the structural roof sheathing 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.

5.2.10. 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 conditioned area. Alternatively, the air shall be supplied by a supply fan when the conditioning system is operating.

5.3. Where wood shingles or shakes are used, a minimum 1/4-inch vented airspace separates the shingles or shakes and the roofing underlayment above the structural sheathing.

5.4. Where Item 5.1 vapor retarder is applied on the ceiling side of the unvented attic assembly, or on the ceiling side of the unvented enclosed roof framing assembly, or on the ceiling side of the unvented enclosed attic assembly, air barrier(s) shall be installed in accordance with Item 5.2.

Following R806.5 Part 5.1.1

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.
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.

Why Closed Cell Foam?

- Unvented conditioned attics can be constructed by installing low density open cell or high density closed cell spray foam directly to the underside of the roof deck (Figure 5). Both foam types work in most climates. In IECC Climate Zones 5 and higher only high density closed cell spray foam should be used.
Following R806.5 Part 5.1.3

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.

- 5.3. 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.

Table R806.5 Insulation for Condensation Control

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>DEMAND FACTOR</th>
<th>MINIMUM R-VALUES</th>
<th>R-VALUES (L2, L3, L4)</th>
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</table>

Following R806.5 Part 5.1.3

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4" XPS R-20 INSULATION
2x12 RAFTER
R-20 BATT INSULATION
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Ceilings Without Attic Spaces – Limited Area

- Where Section N1102.2.1 requires insulation R-values greater than R-30 in the ceiling and the design of the roof/ceiling assembly does not allow sufficient space for the required insulation, the minimum required insulation R-value for such roof/ceiling assemblies shall be R-30. Insulation shall extend over the top of the wall plates or the top edge of the wall and shall not be compressed.

This reduction of insulation from the requirements of Section N1102.1.2 shall be limited to 500 square feet or 20 percent of the total insulated ceiling area, whichever is less.


Cathedral ceilings: R-30 insulation, for up to 75% of the total living space square footage area

PA002.2 Ceilings without attic spaces. Where the design of the roof/ceiling assembly does not allow sufficient space for the required insulation, such as cathedral ceilings, the minimum required insulation for such roof/ceiling assemblies shall be R-30. Insulation shall extend over the top of the wall plate to the outer edge of such plate and shall not be compressed. Insulation from the requirements of Section PA001 shall be limited to 75% of the total living space square footage area.


Summary

• Top chord depth needs to accommodate the full depth of R-30 insulation and eave baffle without compression.
• Specify the specific eave baffle that works for your situation

Questions?
www.phrc.psu.edu
Resources

- Building a Vaulted, High-Performance, and Foam-Free Roof Assembly - https://www.youtube.com/watch?v=93b20o07T

Cathedral Ceiling Assemblies

www.phrc.psu.edu