New *IBC* Rules for Insulation
in Unvented Enclosed Roof Framing Assemblies

by Anthony J. Nicastro, PE, and Megan A. Toumanios, PE

Photo © BigStockPhoto.com

LOW-SLOPE AND STEEP-SLOPE UNVENTED ROOF SYSTEMS (*I.E.* INSULATION AND AIR BARRIER ARE APPLIED DIRECTLY TO THE UNDERSIDE OF THE ROOF DECK) ARE COMMON IN APPLICATIONS WHERE DESIGNERS ARE SEEKING COST-EFFECTIVE AND ENERGY-EFFICIENT ROOF ASSEMBLIES. HOWEVER, ARCHITECTS OF THESE 'COMPACT' ROOF ASSEMBLIES MUST CONSIDER VAPOR PERMEANCE AND ARRANGEMENT OF THE MATERIALS TO PRODUCE ACCEPTABLE HYGROTHERMAL PERFORMANCE AND LOW RISK OF CONDENSATION IN THE RESULTING CONDITIONED 'ATTIC' SPACE. TO THIS END, THE 2015 VERSION OF THE *INTERNATIONAL BUILDING CODE* (*IBC*) INCLUDES NEW PROVISIONS THAT RELATE TO UNVENTED ENCLOSED RAFTER/ TRUSS ASSEMBLIES AND UNVENTED ATTICS. THESE RULES, ESPECIALLY IN SECTION 1203.3, "UNVENTED ATTIC AND UNVENTED ENCLOSED RAFTER ASSEMBLIES," DICTATE HOW DESIGN PROFESSIONALS SPECIFY VAPOR RETARDERS AND PLACEMENT OF INSULATION IN COMPACT ROOF ASSEMBLIES FOR MOISTURE CONTROL.

Most requirements for roofing and thermal efficiency in *IBC* are contained in Chapter 13, "Energy Efficiency," or Chapter 15, "Roof Assemblies and Rooftop Structures." However, Chapter 12, "Interior Environment," addresses, among other topics, ventilation and temperature control. Further, the relationship of unvented attic spaces to maintaining the interior environment through use of insulation is also discussed in Chapter 12, a section seldom associated with roofing materials. Insulation requirements for roofs are, therefore, spread across *IBC* Chapters 12, 13, and 15.

Applicable roofing assemblies

Designers may view unvented 'attic' (*i.e.* attic space, enclosed rafter, or joist space above normally occupied and conditioned interior space) assemblies as an economical arrangement of roofing and insulation materials. However, insulation placement in roof assemblies requires careful review to achieve acceptable hygrothermal performance levels and limit the potential for condensation within the system. Recent *IBC* changes to section 1203.3 recognize successful arrangements of insulation with respect to permeable and impermeable materials, providing design directive to help limit potential failure due to condensation.

IBC dictates acceptable placement and composition of roofing materials in Chapter 15, but describes required thermal efficiency of the roof in Chapter 13, which references the *International Energy Conservation Code* (*IECC*). The minimum required thermal resistance varies depending on insulation placement relative to other materials. Possible locations for insulation within the roof assembly, as addressed by *IBC*, include:

- insulation tight to the roof deck (*i.e.* insulation entirely above the roof deck, directly below the roof deck, or both above and below the roof deck); and
- insulation on the floor of the attic (Figure 1).

It is important to note when insulation is on the floor of the attic, the space between the insulation and the roof deck must be vented to the exterior. This insulation strategy has not changed in recent code iterations and is not discussed in this article.

New rules and practical interpretation

IBC section 1203.3 outlines the only circumstances when a roof may have an unvented attic or enclosed rafter/truss assembly. Although not expressly defined, the authors' interpretations are that this provision applies to both steep-slope and low-slope roof assemblies. Below is a reproduction of the code text and the authors' interpretation along with potential reasoning for each provision.

Section 1203.3 says unvented attics (where ceilings are applied directly to the underside of the roof framing members) are permitted when all of the following conditions are met.

1. The unvented attic space is completely within the building thermal envelope.

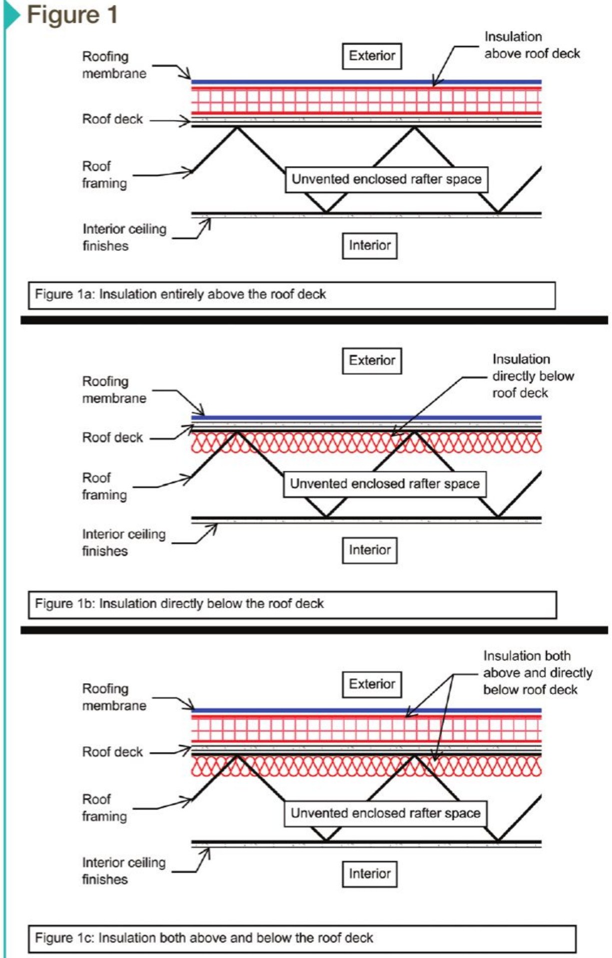
Authors' interpretation: The roof insulation and air barrier must follow the plane of roofing materials rather than diverge (Figure 2, page 18). When all of the insulation is tight to the roof deck, the unvented enclosed rafter/truss assembly or unvented attic is within the building envelope and the attic will be conditioned to have a similar temperature as the interior space. Such a provision limits extreme temperatures in the attic space so pipes remain above freezing to reduce wear and tear on HVAC equipment that is commonly housed in attic space.

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.

The corresponding code commentary reproduced below provides vital clarification of this statement.

Commentary: Item 2, which applies to all climate zones, prohibits the installation of a vapor retarder where it is typically

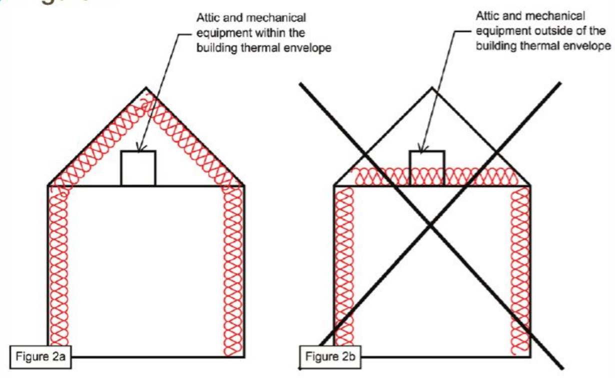
Figure 1



Roof insulation configurations for unvented rafter/truss assemblies.

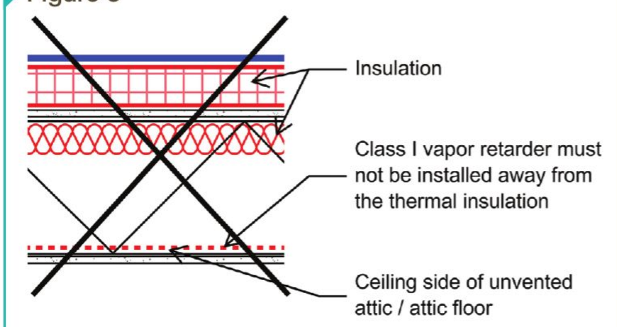
Images courtesy Simpson Gumpertz & Heger

Figure 2



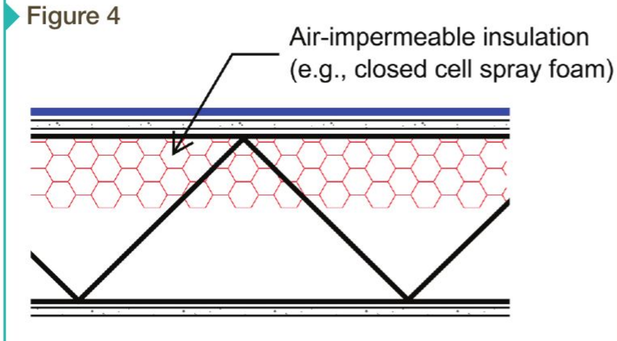
Roof insulation must be at the top of the attic or rafter/truss space as shown in the image on the left, not on the floor of the attic or rafter/truss space as shown on the right.

Figure 3



Incorrect placement of a Class I vapor retarder in the roof assembly.

Figure 4



As illustrated in this image, air-impermeable insulation must be tight to the underside of the roof deck.

installed at the ceiling level (attic floor) of a traditional ventilated attic. This assures that no barrier is installed which would separate the conditioned attic area from the remaining portion of the home. This requirement gives the attic space a limited potential to dry into the space beneath the attic so that small amounts of excess moisture can be removed from the attic.

Authors' interpretation: Vapor retarders limit vapor diffusion and, when properly placed, can prevent the formation of condensation on interior surfaces. Examples of Class I vapor retarders include polyethylene film or foil-faced insulation. When improperly placed within a roofing assembly or combined with another strong vapor retarder, such as a roof covering, they may lead to condensation or trapped moisture. Barring use of a Class I vapor retarder on the attic floor of the roof assembly seeks to limit the potential for trapped moisture from accumulating in the attic space (Figure 3).

3. Where wood shingles or shakes are employed, a minimum 1/4-in. (6.4-mm) vented airspace separates the shingles or shakes and the roofing underlayment above the structural sheathing.

Authors' interpretation: Providing a ventilation layer, specifically below wood shingles or shakes, allows back-drying of the wood shingles or shakes between rain events to limit moisture accumulation in the roof assembly and wood decay.

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.

Authors' interpretation: Inclusion of a Class II vapor retarder on the winter-warm side of the assembly produces favorable hygrothermal performance and lowers risk of condensation in cold climates.

Examples of air-impermeable insulation include expanding sprayfoam (open- and closed-cell) and insulated sheathing panels. Open- and closed-cell sprayfoams may be air impermeable when installed in thicknesses greater than manufacturers' minimum requirements. Closed-cell sprayfoam may form a Class II vapor retarder at certain minimum thicknesses, while open-cell sprayfoams are generally vapor permeable.

Air-permeable insulations include fiberglass batts, semi-rigid mineral wool boards, and most cellulose insulation products.

5. Insulation shall be located in accordance with the following:
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.

Authors' interpretation: If insulating below the roof sheathing deck, designers must select an approved insulation method described in the subsections.

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.

Authors' interpretation: Insulation that does not allow air movement through it (*e.g.* closed-cell sprayfoam) must be located on the underside of the roof deck (Figure 4).

5.1.2. Where air-permeable insulation is provided inside the building thermal envelope, it shall be installed in accordance with Item 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 1203.3 for condensation control.

Authors' interpretation: An air-permeable insulation, such as a fiberglass batt, on the underside of the roof deck must be used in conjunction with insulation above the roof deck (*i.e.* 'split insulation' assembly). Table 1203.3 lists minimum R-values of air-impermeable insulation to be used for each climate zone to limit potential for condensation within the roof assembly (Figure 5, page 20).

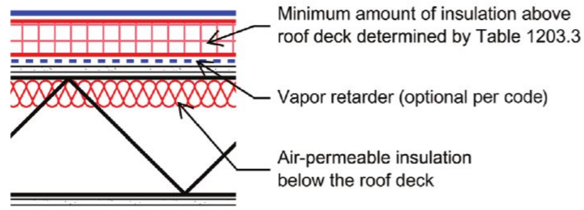
The values in Table 1203.3 must be used in conjunction with the total R-value required in *IECC*. Also, this provision does not presume or exclude a vapor retarder applied to the top of the roof deck. Some roof assemblies with split insulation require project-specific analysis using hygrothermal computer modeling software to predict whether a vapor retarder should be included on the structural deck or not.

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 1203.3 for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.

Authors' interpretation: Where both air-impermeable and air-permeable insulation are below the roof deck, the air-impermeable insulation must be tight against the roof deck. The minimum amount of air-impermeable insulation required is listed in Table 1203.3. The air-permeable insulation must be tight to the underside of the air-impermeable insulation (Figure 6, page 20). The need for a vapor retarder in this assembly is discussed in Item 4 above.

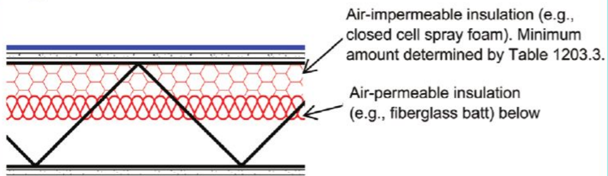
5.1.4. Alternatively, sufficient rigid board or sheet insulation shall be installed directly above the structural roof sheathing to maintain the monthly average temperature of the under-side of the structural roof sheathing above 45 F (7 C). For calculation purposes, an interior air temperature of 68 F (20 C) is

Figure 5



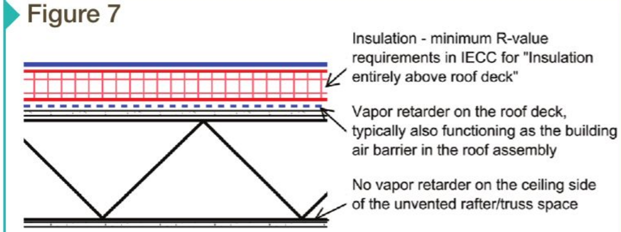
Air-permeable insulation below the roof deck requires rigid board insulation above the roof deck (minimum amounts determined by Table 1203.3 of the *International Building Code* [*IBC*]-2015 based on climate zone).

Figure 6



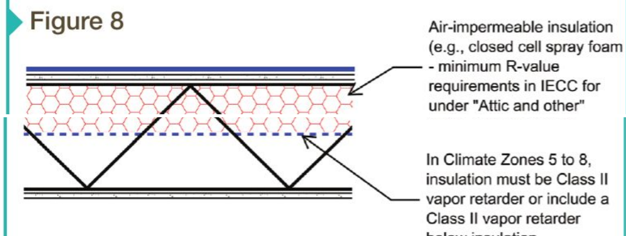
Air-impermeable insulation must be tight to the underside of the roof deck with air-permeable insulation below.

Figure 7



Roof assembly with insulation entirely above the roof deck.

Figure 8



Roof assembly with air-impermeable insulation entirely below the roof deck.

assumed and the exterior air temperature is assumed to be the monthly average outside air temperature of the three coldest months.

Authors' interpretation: Adding insulation above the structural roof sheathing increases the temperature of the structural roof sheathing during cold winter months. Designers who comply with 5.1.4 may use a combination of insulation—when used with rigid board insulation—if a computer software model can demonstrate the average temperature of the roof sheathing meets the stated criteria. Such simplified and prescriptive criteria is an indicator of resistance to condensation on interior surfaces given relative humidity (RH) within the operating parameters described earlier in the section (*e.g.* less than 35 percent). Air at 20 C and 35 percent RH has a dewpoint of 1 C (39 F), which is safely lower than the 7 C threshold required by this provision. The given boundary conditions capture a reasonable degree of situations for non-humidified buildings. Humidified buildings are excepted from these provisions and require their own project-specific analysis.

5.2. 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.

Authors' interpretation: The seams at the interior surface of an air-impermeable board insulation placed below the structural deck must be sealed to create a continuous air barrier at the interior surface, thereby preventing interior conditioned air from penetrating through or partially through the insulation layer at seams.

Note the 2015 *IBC* errata issued on November 16, 2015, changes the text in Item 5.2 from "air-permeable" to "air-impermeable."

Exceptions

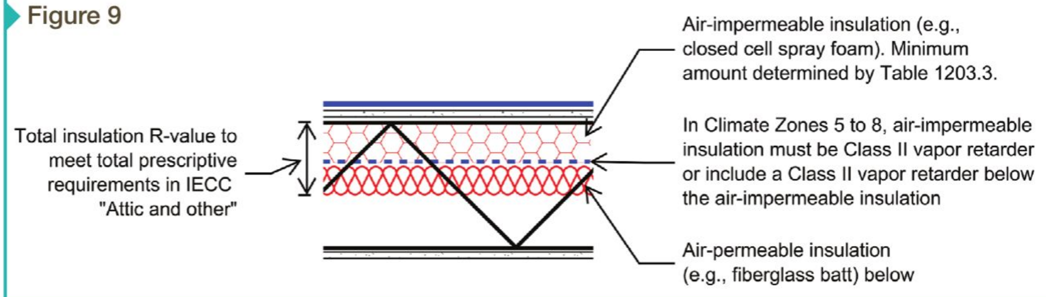
1. Section 1203.3 does not apply to special use structures or enclosures such as swimming pool enclosures, data processing centers, hospitals, or art galleries.
2. Section 1203.3 does not apply to enclosures in Climate Zones 5 through 8 that are humidified beyond 35 percent during the three coldest months.

Authors' interpretation: Special-use buildings or those with elevated interior RH require special engineering. Prescriptive guidelines of this section do not apply. For instance, interior RH can create a strong vapor drive from interior to exterior in winter, creating the need for a Class I winter-warm side vapor retarder, omitted from this section.

Options for contemporary unvented roofs

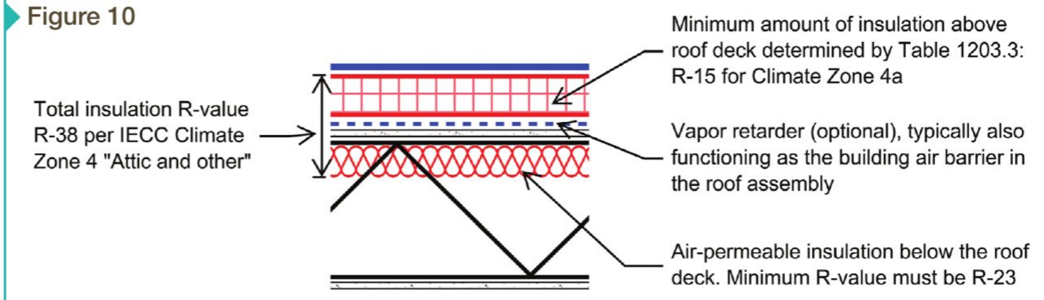
Designers may be confused by the numerous and lengthy requirements contained in section 1203.3. To help, below are some examples of roof assemblies for unvented rafters/trusses or unvented attics meeting the new code requirements, illustrated for simplicity. The examples below are only meant to illustrate code requirement of section 1203.3, and do not address any other rules (*e.g.* applicable fire code requirements) that may be triggered.

Figure 9



Roof assembly with air-impermeable and air-permeable insulation entirely below the roof deck.

Figure 10



Roof assembly with insulation both above and below the roof.

Insulation entirely above the roof deck

Placing all of the *IECC* code-required insulation above the roof deck with a vapor retarder will provide acceptable hygrothermal performance in all climate zones (Figure 7, page 20). This meets the requirements of Section 5.1.4.

Insulation entirely below the roof deck

Section 1203.3 pushes designers away from having all the insulation between ceiling finishes and roofing in an unvented assembly. Designers pursuing this arrangement of insulation must be aware of several caveats. If insulation is entirely

ADDITIONAL **INFORMATION**

Authors

Anthony J. Nicastro, PE, is a senior project manager with Simpson Gumpertz & Heger, Inc. in Washington, DC. As a member of the building technology group, he has national experience in the investigation, design, and construction contract administration of building enclosure components for major institutional, commercial, educational, and residential buildings. Nicastro can be reached at AJNicastro@sgh.com.

Megan A. Toumanios, PE, is a consulting engineer with Simpson Gumpertz & Heger, Inc. in Washington, DC. She works in the building technology group on projects involving building enclosure design, rehabilitation, and investigation. Toumanios can be reached at MAToumanios@sgh.com.

Key Takeaways

Unvented roof systems, where the insulation and air barrier are applied directly to the underside of the roof deck, are common in applications where designers are seeking cost-effective and energy-efficient roof assemblies. However, designers of compact roof assemblies must consider vapor permeance and arrangement of the roofing materials to produce acceptable hygrothermal performance and low risk of condensation in the conditioned attic space. To this end, the 2015 version of the *International Building Code (IBC)* includes new provisions relating to unvented attic and unvented enclosed rafter assemblies that dictate how designers specify vapor retarders and placement of insulation in compact roof assemblies for condensation control.

MasterFormat No.

07 21 00–Thermal Insulation
07 26 00–Vapor Retarders

UniFormat No.

B1020.10–Roof Structural Frame
B1020.90–Roof Construction Supplementary Components

Key Words

Division 07
Insulation
International Building Code
Unvented roof systems
Vapor retarder

below the deck, some of it must be air-impermeable, typically an expansive sprayfoam. If only providing air-impermeable insulation, it must be applied directly to underside of roof sheathing, per Item 5.1.1 (Figure 8, page 20). Continuity of the insulation layer in these assemblies is very critical to performance. Note that sometimes continuous insulation below the roof deck may conceal or trap water leakage resulting from a defect in the roof covering.

Alternatively, insulation entirely under the roof deck can be composed of a combination of air-impermeable and air-permeable insulation in order to meet the requirements of 5.1.3. The impermeable insulation must be in direct contact underside of deck, while air-permeable insulation is installed directly below (Figure 9). Table 1203.3 describes minimum insulation value of the air-impermeable layer of insulation for condensation control when combining air-impermeable and air-permeable insulation below the deck that meet the prescriptive *IECC* code-required insulation thickness. For most practical combinations of insulation layers, this arrangement will protect the assembly from condensation. However, adding a large amount (*i.e.* well beyond the prescriptive *IECC* code-required insulation thickness) of air-permeable insulation, which is often not a vapor retarder, may draw the dewpoint inward during cold, winter months, potentially increasing the risk for moisture accumulation.

Insulation both above and below the roof deck

Split insulation assemblies are subject to sections 5.1.2 or 5.1.4. The code offers prescriptive requirements in Table 1203.3, that clarifies the minimum amount of insulation above the roof deck based on the climate zone. It is important to note the code requires progressively more insulation above the roof deck as the design climate zone becomes colder, thereby keeping the plane of the structural deck sheathing above the dewpoint (Item 5.1.2).

Alternatively, less insulation can be provided above the roof deck, provided a performance-based analysis illustrates the temperature of the interior surface of the roof sheathing is maintained above 7 C under normal operating conditions (Item 5.1.4).

Designers must comply with both the insulation values above the deck and total insulation amount prescribed in *IECC,* which anticipates that insulation categorized as "attic and other" will be interrupted by studs, so designers may rearrange some portion of the total insulation to be on top of the structural sheathing deck while still adding insulation amounts in series (*i.e.* simple addition of R-values rather than a U-factor calculation that calculates area-weighted contributions of thermally different members in parallel).

The code does not prescribe or bar use of a vapor retarder on the structural deck sheathing in this instance. Designers use their judgment to determine whether the vapor retarder is required to limit vapor diffusion and potential formation of condensation. Figure 10 shows an example roof assembly for a roof in Climate Zone 4a.

Conclusion

These new requirements in section 1203.3 place restrictions on roof assemblies with insulation below structural roof decks in unvented spaces, as the code recognizes the risk of condensation on interior surfaces. In many cases, simple rearrangement of insulation to the top of the structural deck will satisfy these requirements. When insulation must be placed in an unvented attic, designers would have to provide supporting analysis demonstrating materials inside the building enclosure remain above the dewpoint. For any arrangement of roofing and insulation materials unfamiliar to the designer, computer modeling and further consulting is a prudent choice regardless of new requirements in section 1203.3. **CS**