Photos courtesy Building Science Corporation

Avoiding Wet Roofs, Part 2

Accepted practice and new methods for unvented roofs

BY PETER YOST

This is the second article in a two-part series on the performance of attics and roofs. In Part 1, we introduced the options available to builders and remodelers and explained some of the building science that comes into play. In this second article, we dive into the code issues and introduce some exciting new research in this field.

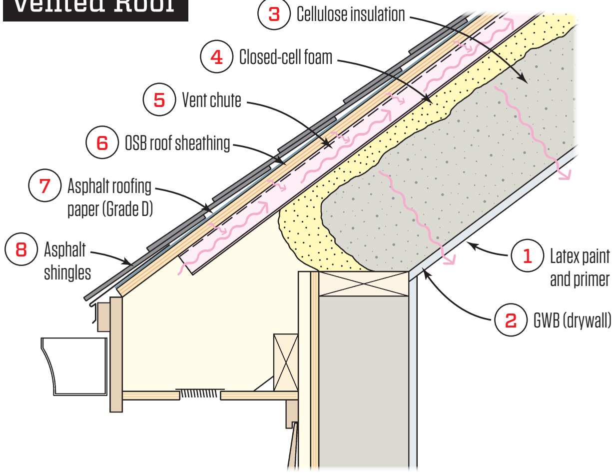
ATTIC AND ROOF VENTING IN THE CODE

Nearly everyone in the building industry knows the 1:300 or the 1:150 vent ratio the code includes (see IRC 2015 Section R806 Roof Ventilation; R806.2 Minimum vent area): "The minimum net free ventilating area shall be 1/150 of the area of the vented space."

Just where did this ratio come from? We turn to Bill Rose, whom I am dubbing *the* building-science historian, to answer that question. In his book, *Moisture in Buildings*, Rose states: "A single data point in a single piece of research predated the introduction of attic ventilation as a strictly (i.e., numerically) regulated practice. That data point did not make a convincing case for attic ventilation as a broadly applied practice."

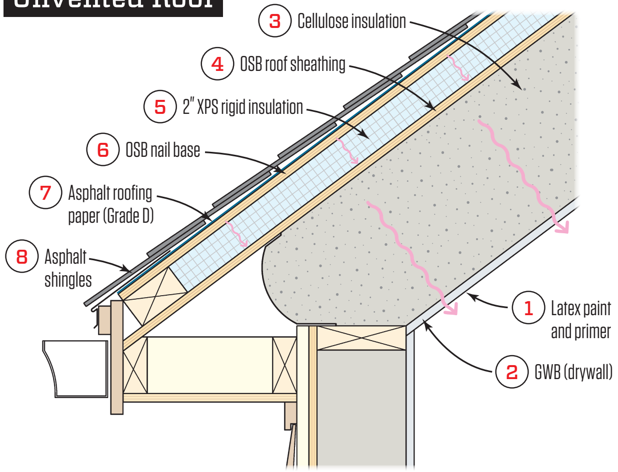
While everyone knows about this ventilation requirement, no one really knows if it translates into significant or even adequate moisture management, or under what conditions this level of attic

Vented Roof



1	Latex paint and primer	5 perms	Class III retarder
2	GWB (drywall)	40 perms	Vapor open
3	Cellulose insulation	75 perms	Vapor open
4	Closed-cell spray foam	1 perm	Class II retarder
5	Vent chute	300 perms	Vapor open
6	OSB roof sheathing	2 perms	Class III retarder
7	Asphalt roofing paper	30 perms	Vapor open
8	Asphalt roofing shingles	.65 perm	Class II retarder

Unvented Roof



1	Latex paint and primer	5 perms	Class III retarder
2	GWB (drywall)	40 perms	Vapor open
3	Cellulose insulation	75 perms	Vapor open
4	OSB roof sheathing	2 perms	Class III retarder
5	2" XPS rigid insulation	.5 perm	Class II retarder
6	OSB nail base	2 perms	Class III retarder
7	Asphalt roofing paper	30 perms	Vapor open
8	Asphalt roofing shingles	.65 perm	Class II retarder

Excellent drying. The least vapor-permeable components in this assembly are the asphalt roofing shingles (Class II; little to no drying) and the closed-cell spray foam (Class II). Moisture-sensitive OSB structural sheathing is between them. However, the vent chute, even without stack-effect-driven air movement, has a vapor permeance of 300 perms (just diffusion). This assembly has excellent drying potential for the OSB to the exterior. And for all of the components to the interior of the closed-cell spray foam, there is excellent drying potential to the interior.

Limited drying. The least vapor-permeable components of this assembly are the asphalt roofing shingles (Class II) and the XPS rigid insulation (Class II). If the nail-base sheathing between them should ever get wet, it will not dry to the exterior at all and will have limited drying to the interior. The structural sheathing will have little to no drying potential to the exterior but good drying potential to the interior. With an interior Class III vapor retarder and only 2 inches of rigid insulation on the exterior, this assembly, as drawn, would be limited to warmer climate zones.

ventilation has meaning. Translation? There is nothing magical about the code's venting ratios.

Provide as much free vent area as you can, and increase the effectiveness of the venting by locating half of it as low as you can and the other half as high as you can in your attics and roofs. Remember that any vapor profile that includes convective drying (airflow provided by venting) is a best practice for high-performance roof assemblies.

UNVENTED ATTICS AND ROOFS

Unvented assemblies are relatively new to the building code and a lot more complicated. Section R806.5 of the 2015 IRC, titled "Unvented attic and unvented enclosed rafter assemblies," states that the attic or roof assembly can be unvented if five conditions are met.

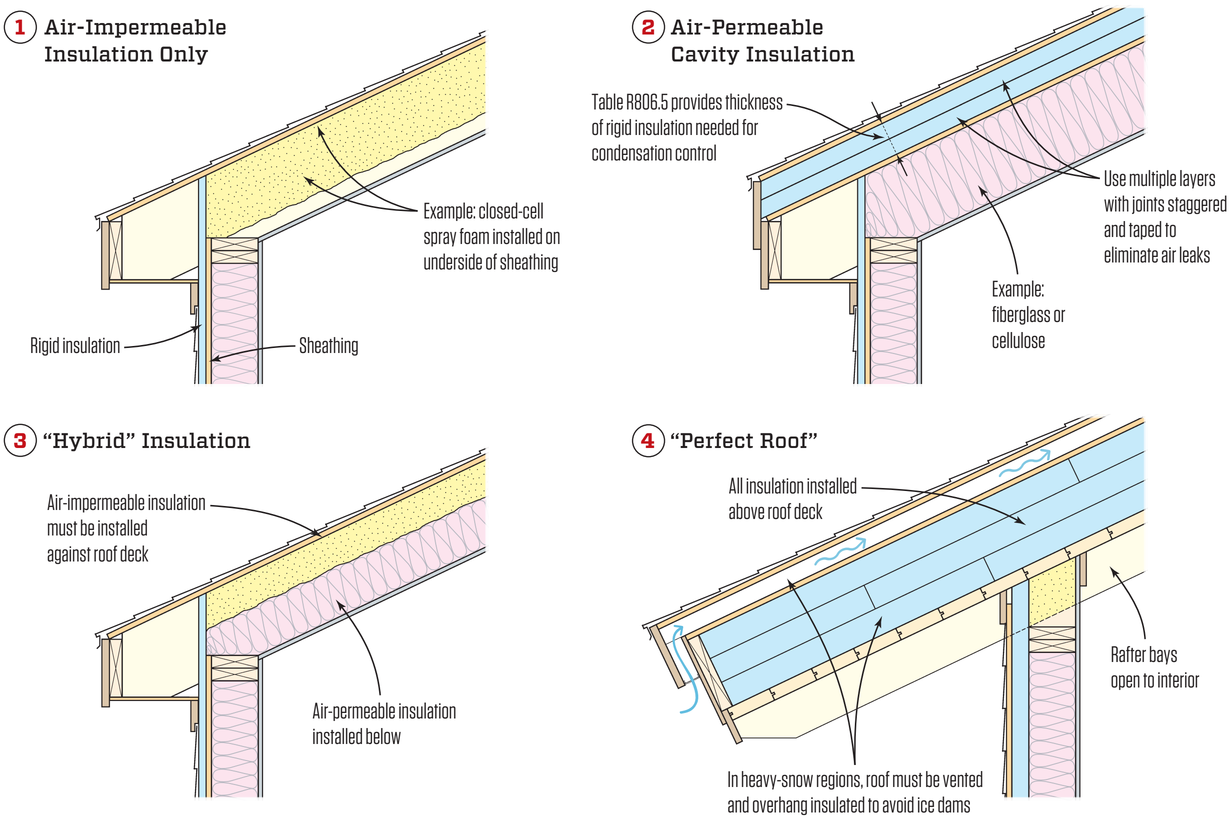
The first four conditions are relatively straightforward:

1. The attic or roof assembly is completely within the building thermal envelope.
2. There is no Class I vapor retarder at the ceiling plane.
3. If present, wood shakes and shingles must be separated from the roof sheathing by a minimum 1/4-inch (6.4mm) vented air space.
4. In Climate Zones 5 to 8, air-impermeable insulation must be (or have) a Class II vapor retarder on the underside of the insulation or assembly.

Here is my interpretation of these first four conditions:

1. You must have a continuous air-control layer as part of any unvented attic or roof assembly.
2. Because many unvented roof assemblies have topside elements (such as roof underlayments and cladding) that are Class I

Illustration: Tim Healey/Steven Baczek



Insulation options for unvented roofs. When you're using only air-impermeable insulation (option 1, top left), it must be installed directly below the roof deck. When you're using only air-permeable insulation in the framing cavity (option 2, top right), you must install the right amount of rigid insulation above the roof deck. Wood roofing will still need a minimum vent space beneath it. When you're using a mix of air-permeable and air-impermeable insulations in the framing cavity (option 3, above left), the air-impermeable material must be installed directly below the roof deck. All the insulation can be installed over the roof deck with the framing cavities left open (option 4, above right). In snow regions, the roofing will still need to be vented.

Illustration: Tim Healey

vapor retarders, you don't want an interior Class I vapor retarder that virtually eliminates drying to the interior.

3. Roof claddings made out of wood require special attention to drying.
4. Cold climates mean unvented roof assemblies need a bit greater control of warm, moist air moving into the unvented assembly during the winter.

The fifth condition is all about the insulation in the space and assembly. It's complicated because it deals with the type of insulation (air-impermeable or air-permeable), the location of the insulation (exterior or interior to the roof sheathing), and balance (by R-value) of the types of insulation for assemblies with *both* air-impermeable and air-permeable insulation.

Here is my summary of this fifth condition (R806.5.5):

1. If you are using only an air-impermeable insulation (for example, closed-cell spray foam), it must be installed on the underside of the roof sheathing and in direct contact with the sheathing (no chance for air-control-layer discontinuity).
2. If you use air-permeable cavity insulation (batts, blow-in or sprayed cellulose or fiberglass), you must install enough rigid insulation on top of the roof sheathing to provide condensation control (Table R806.5 sets up the R-value ratios by climate that define how thick this rigid insulation needs to be).
3. If you choose a "hybrid" insulation system, the air-impermeable insulation must be against the roof sheathing, and the R-value ratio of air-impermeable to air-permeable insulations must follow Table R806.5 for condensation control.
4. You can do a "Perfect Roof" with rigid foam only above the sheathing and with open framing cavities. (The term "Perfect

Roof" was coined by Joe Lstiburek, who has also worked out important details for this assembly in snow regions. See the Building Science Corp. (BSC) article "Joseph Haydn Does the Perfect Wall" for more information.) If you put all your R-value topside of the roof sheathing, that topside insulation can give you enough condensation control (per 2015 IRC Table 806.5) to leave the roof assembly empty and completely open to drying to the interior.

Yes, the building code is getting more complex, but the code is integrating the immutable building-science relationships between energy, moisture, wetting, and drying. If the code is asking more of the building in terms of energy and moisture management, that means it has to ask more of the building professionals designing, spec'ing, and constructing these assemblies.

THE COOLEST THING JOE HAS DONE

Joe Lstiburek has done a ton of cool things over the years (like teaching me—and a whole tribe of others—more about buildings than anyone else in the industry). But developing and researching "vapor diffusion ports" for unvented roof assemblies is just about the coolest thing he has done, in my opinion.

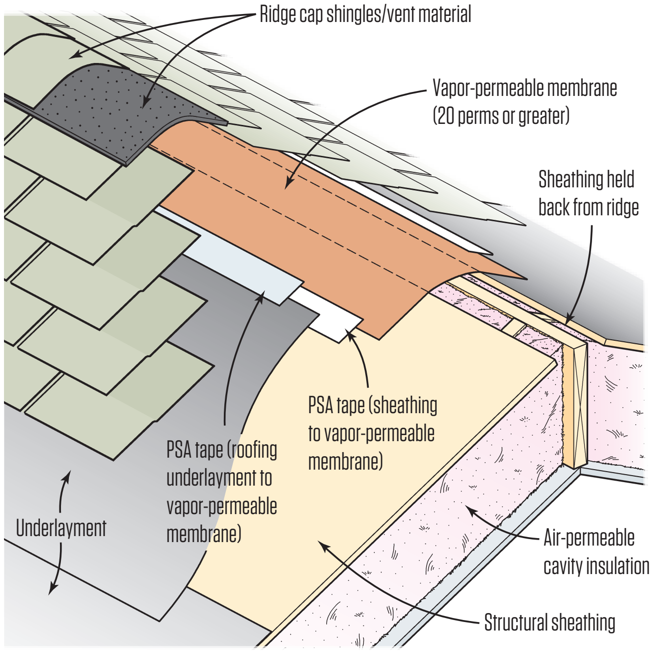
Based on SIP roof failures with moisture concentrating at the ridge (see BSC's "Complex Three Dimensional Airflow Networks"), Lstiburek came up with a way to vent moisture in unvented roof assemblies when the roof assemblies are packed with air-permeable insulation: using vapor-diffusion ports at the ridge of sloped roofs.

With the support of a host of other parties (including Building America, Dörken, DuPont, NAIMA, NuWool, K. Hovnanian, and David Weekley Homes), Lstiburek and BSC have done the field research to fully develop vapor diffusion ports for unvented roofs. This work is now reflected in the 2018 model codes, at least for climate zones 1 to 3. Per section R806.5.5.2, you can use air-permeable insulations in unvented roof assemblies in these climates so long as:

1. You include vapor diffusion ports located within the highest 12 inches of the sloped roof.
2. The ports comprise an area equal to or greater than 1:600 of the ceiling area.
3. The vapor-permeable membrane over the ports has a vapor permeance equal to or greater than 20 perms.
4. The vapor diffusion port is part of a continuous air barrier in the unvented roof assembly.
5. The vapor diffusion port still protects the roof from blowing rain and snow.

This all gets trickier in cold climates, so BSC has been conducting field research to determine just how the details of a vapor diffusion port will need to change for cold

Vapor Diffusion Port



Vapor diffusion port. In climate zones 1 to 3, installing vapor diffusion ports allows you to use air-permeable insulation only in an unvented roof (illustration, top). The ports **(1)** must be installed to maintain the air barrier on the lid of the building and to keep out blowing rain and snow. Vapor diffusion ports are located at the top of the roof and designed to relieve water vapor. They can be retrofit on an existing roof by converting an existing ridge vent, but you will need to cover it with a vapor-open air barrier and block off any soffit vents or other vents lower on the roof.

Illustration: Tim Healey / Building Science Corp.

Test hut. To learn how vapor diffusion ports might work in cold climates, Building Science Corp. is conducting ongoing research in this test hut. The framing bays in the roof **(2)** have been separated by isolation bays that have been tightly sealed with spray foam. In each unsealed bay, the research team has installed different combinations of air-permeable cavity insulation, vapor-open and vapor-closed ceiling vapor retarders, air barriers, and diffusion ports to evaluate the complex set of variables acting on unvented roofs **(3)**.

climates. Some of the strategies and considerations the BSC team is working on for cold climates include greater vapor permeance of the diffusion membrane; greater square area of the ports; the impact of different air-permeable cavity insulations; the impact of higher interior wintertime relative humidities. The photos at left show the BSC test hut where BSC is currently conducting much of this research.

When I asked Joe Lstiburek and Kohta Ueno of BSC when cold-climate vapor diffusion ports would be ready for building-code primetime, they both said it needs at least another year or two of data before any IRC code change proposals, but changes to the IBC may come earlier.

A word of caution regarding building science and the codes: There are limits to any prescriptive measure. Prescribing a building-science solution is incredibly difficult because the best answer to almost every building-science question is: “It depends” (another building-science truism popularized by Joe Lstiburek). In a roof assembly, there are too many variables in play that affect energy, moisture, durability, and IAQ (indoor air quality). A prescriptive code cannot capture them all. Compliance with code is not enough. You still have to use a strong understanding of building science and use your own judgment as you balance wetting and drying, complexity, and cost—all of which are specific to your climate, your trade partners, and your sites.

ATTIC AND ROOF RULES TO BUILD BY

Despite the difficulty of prescribing a one-size-fits-all fix for wet roofs, we can boil this down to a few guidelines:

1. Vent attics and roofs until you can’t.
2. Simple roofs are more forgiving than complex ones; avoid gratuitous complexity.
3. Select materials for your roof assemblies from manufacturers that provide comprehensive hygrothermal performance data, *and*
4. Choose manufacturers willing to work with you on how their materials perform in combination with all the other components of the assembly.
5. Worry about your continuous control layers in this order: water, air, vapor, thermal.
6. Having said that: The air control layer seems to get short shrift because air leaks are sneakier than water leaks. Make your roofs airtight.
7. Do not vent to manage air leakage; this is a losing proposition.
8. Manage energy and moisture with equal intensity. It’s not just a good idea; it’s the law.

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