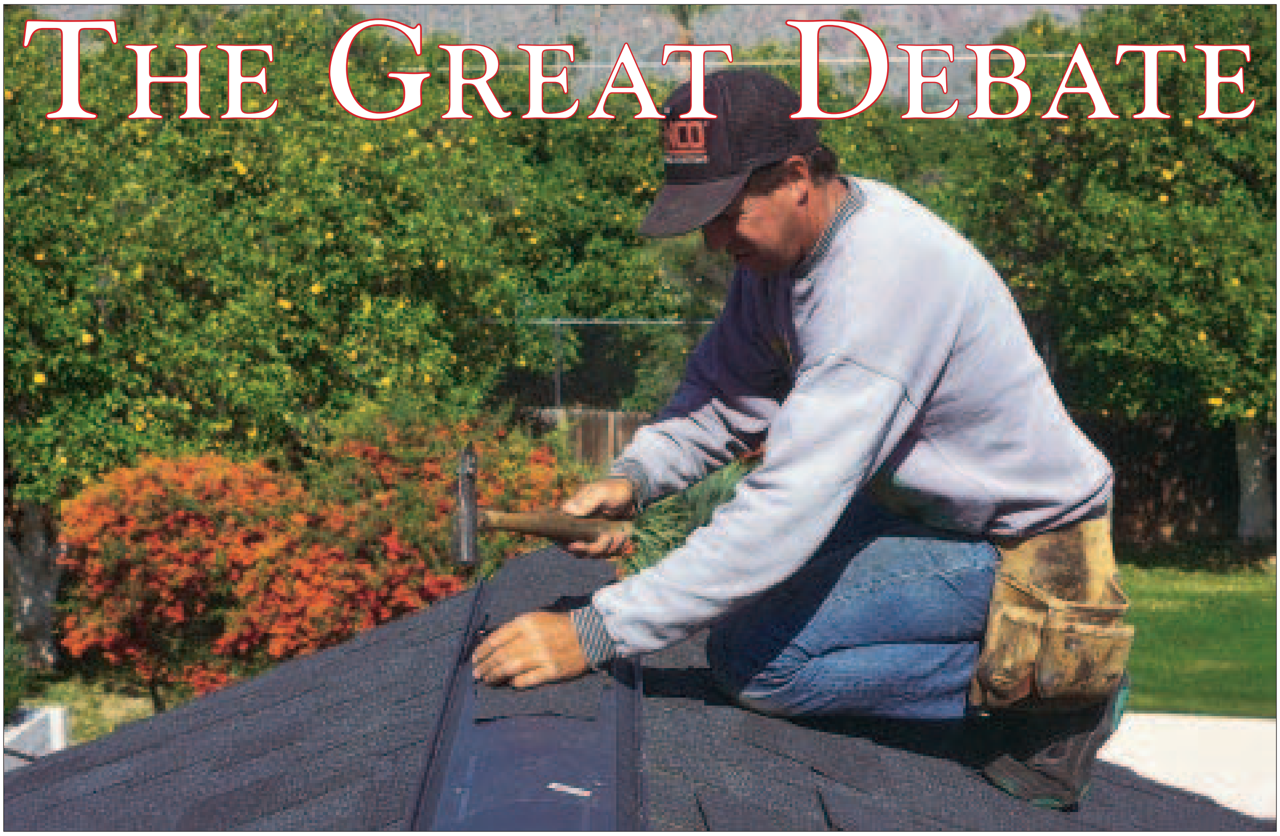
Vented vs. Unvented Roofs: The Great Debate



For several decades now, every major building code has required roofs to be ventilated. While other areas of the codes have changed and evolved, roof venting rules have remained unchallenged.

Recently, though, some building scientists have been questioning the need for roof ventilation. In researching this article, we pored over many pages of research data, including studies from the United States, Canada, and Sweden. We also considered the experiences of builders who have been trying out a variety of unvented, or "hot roof," designs. Our conclusion is that the strongest evidence, both from the lab and from experience in the field, continues to support the importance of ventilation.

Unvented roofs are possible in theory, but venting is always the safest course, especially in cathedral ceilings

by Ted Cushman

A Little History

According to researcher Bill Rose of the University of Illinois's Building Research Council, the commonly used ratio for venting — one square foot of net free vent area for 300 square feet of attic — dates back to a single experiment conducted by Penn State researcher Ralph Britton in 1947. And although Britton's simple test comparison of three small flat-roof assemblies built in a laboratory climatometer had no provision for duplicating the effect of sunlight, wind, or building air pressures, his "1/300 rule" was adopted nationwide, with no further study.

Up through the 1970s, most homes built according to the 1/300 rule performed well. Building scientist Joe Lstiburek says homes built in those years had few moisture problems because they were leaky and overheated. "A house has to breathe" was the slogan, and houses did: Winter winds easily passed through board sheathing and plaster walls, between cracks in the framing, between foundations and sills, and through leaky windows (Figure). Because there was less insulation in ceilings, heat from the house kept the attic warm enough that condensation was seldom a problem.

In addition, says Lstiburek, large, inefficient boilers and furnaces, with their powerful drafts, gulped indoor air and blew it up the chimney. "Every furnace in those days was also a powerful exhaust-only ventilator." Large volumes of outdoor air, carrying little moisture, were drawn into buildings, heated, and expelled, along with moisture generated by building occupants, leaving building interiors uncomfortably dry in winter.

But the oil crisis of the 1970s changed all that. In response to higher energy prices, homeowners added insulation wherever they could — especially in the attic. New homes built since the mid-1970s have become increasingly tighter and more heavily insulated, and efficient new heating plants create much less suction than the roaring furnaces of the past. Without power ventilation or dehumidification, homes built to today's standards in the northern half of the U.S. have high relative humidity indoors in the winter. And even heavily insulated ceilings contain enough penetrations from light

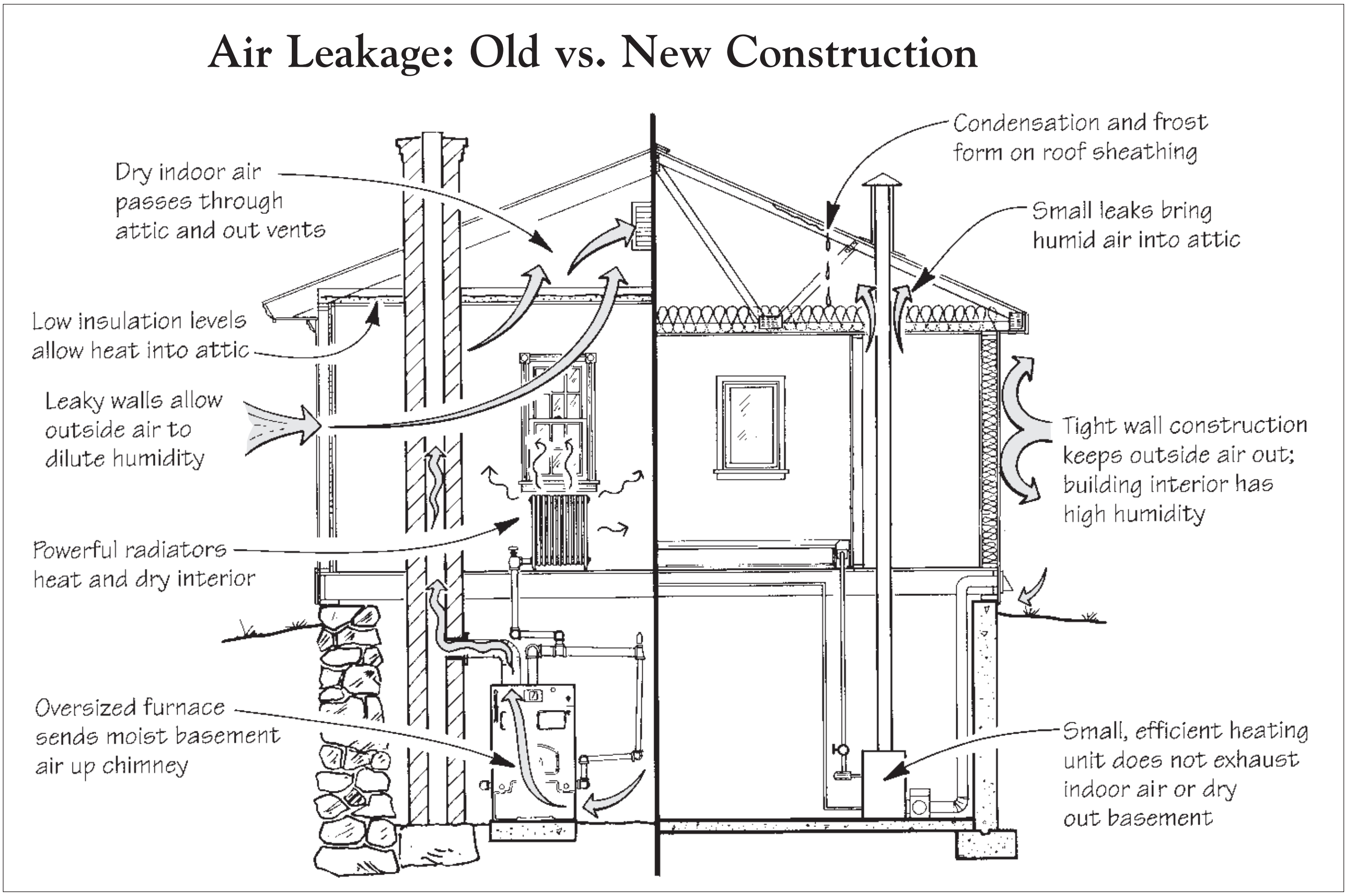


Figure 1. *Heat escaping into the attics of older homes and the drying effect of inefficient heating equipment and leaky building shells tend to minimize condensation problems in the attic. By contrast, modern homes have cooler attics and more humid indoor air, so moisture passing through the ceiling is more likely to condense on the underside of the roof.*

fixtures, plumbing, and wiring to permit a steady trickle of moist, warm air into the cold attic (Figure 2). The too-frequent result: condensation, mildew, and, in the worse cases, rot.

The Search for Solutions

Building scientists looking at today's attic moisture problems typically focus on two issues: indoor humidity and the ceiling air barrier. Lower the home's humidity and seal the boundary between ceiling and attic, they say, and your problem is solved. In fact, some researchers have gone as far as to say that if indoor humidity is controlled and the ceiling is well sealed, attic venting is unnecessary.

Most builders in the field, however, are skeptical. After all, a perfect ceiling air barrier is tough to build — and the homeowner or some future remodeler is likely to penetrate it anyway. Lumber shrinkage or building movement may open up cracks, or the roof may leak. In the long run, many builders reason, moisture will probably find its way into the attic one way or another — and when it does, it needs a way to get out again. Even builders who provide a good air barrier at the ceiling and who design the mechanical system to keep indoor humidity down want a roof vent that works. In most areas, in fact, they are required by code to ventilate. The questions for them are *how much venting* and *what kind of venting* should they provide?

Enter the Scientists

The most comprehensive study to date is still underway at the University of Illinois's Building Research Council under the direction of Bill Rose. With funding from CertainTeed, Rose has built a test building whose roof is divided into ten sections. The two end sections provide buffering against the weather, while in the remaining sections researchers have tested a variety of insulation and venting strategies. Sensors continuously monitor sheathing temperature, moisture content, and attic air temperature and humidity. The rooms below are maintained at the controlled temperatures and humidities, so any performance differences in the roof assemblies can be traced to differences in the way the roofs are vented.

Three of the test sections are cathedral ceiling assemblies insulated to R-36 with fiberglass batts. One has soffit and ridge vents with an air space between the insulation and the sheathing provided by a manufactured foam vent channel. A second roof has the vent channel but no vent openings, and the third has vent openings but is stuffed full of fiberglass, with no vent channel.

The flat-ceiling, full-attic assemblies provide for a similar set of comparisons: One has continuous ridge and soffit vents, a second has soffit vents but no ridge vents, and a third has no venting at all.

Over the six years the test building has been in operation, the researchers have experimented with removing the ceiling vapor barrier from all the different test assemblies. Rose has also observed the effect of penetrations in the ceiling by installing 1½-inch pipe through the ceiling drywall, which can

Common Attic Leaks

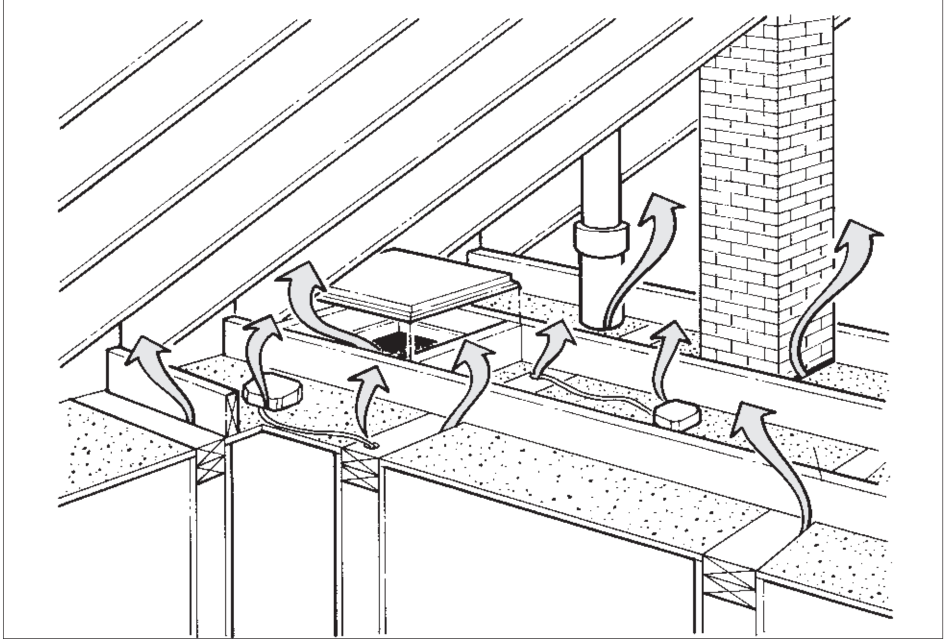


Figure 2. *A typical ceiling has many penetrations that are hard to seal. Roof vents are designed to remove the moisture leaking into the attic through such cracks.*

be uncapped at will to allow indoor air into the cavities above.

Rose has yet to release a final report on his work, but the information he has released to *JLC* in interviews confirms that properly installed roof venting does reduce moisture in roof assemblies.

Attics vs. Cathedral Ceilings

Specifically, Rose's research indicates that buildings with full attics above an insulated flat ceiling show no roof moisture damage — whether or not code-required ventilation is installed. (This *doesn't* include buildings on wet sites with severe basement moisture problems, which can overwhelm even a properly installed venting system.)

Rose says that sheathing on all the attics in his experiment stayed well below saturation moisture levels. "We could not grow mold in any of our attics, no matter how hard we tried," he said. Opening the ceiling penetrations did cause frost to form on the underside of the vented attic's roof on the coldest nights, but Rose considers this effect to be minor, since the frost disappeared during warmer periods.

Cathedral ceilings, however, are another matter. In the cathedral test assemblies, "wherever we had holes in the vapor barrier, we had mold on the sheathing," says Rose. The amount of mold varied, from just a small spot in the less damp assemblies to big blackened areas in the worst cases.

Air Space Crucial

In Rose's test roofs, the air space between the insulation and the sheathing proved crucial to good vent performance. The worst-case cathedral ceiling was the one equipped with ridge and soffit vents but lacking the polystyrene vent channel. When a ceiling hole was uncapped to allow humid indoor air into this "stuffed vented" roof, the assembly suffered "an explosion of mold," says Rose. The instruments indicated that this roof's sheathing stayed saturated for long periods of time.

Not surprisingly, the assembly with a vapor barrier, ridge and soffit vents, and a vent channel had the lowest sheathing moisture level and experienced the least mold growth. But one unexpected result was that even in an assembly with no ridge or soffit vent, the presence of a vent channel that created an air space between the insulation and the sheathing kept the roof sheathing significantly drier.

Rose is unsure how to explain this result, but suggests that when the roof heats up during the day, air in the rafter cavity expands and forces its way out of the assembly through any cracks it can find (even spaces between the shingles), carrying excess moisture with it. When cooler air seeps back in at night, it carries less moisture with it, so the whole assembly tends over time to equalize with the outdoors.

Cooling Performance

In addition to measuring moisture content, Rose also installed temperature sensors on the roof sheathing to measure the cooling effect of vents during the summer months. Unvented cathedral ceilings ran the hottest, reaching sheathing temperatures over 180°F during the experiment's first summer. The unvented attic's sheathing was close behind, at 175°F, slightly hotter than the vented cathedral, at 170°F. The vented attic was next with a top temperature for the year of 165°F, very close to the mark reached on the north side of the unvented cathedral. But the coolest roof by far was a vented attic with white shingles, which got no hotter than 148°F all summer.

"Venting always cools the roof," concludes Rose. But he notes that venting is less important than roof orientation or shingle color in determining roof temperature. In the cathedral assemblies, Rose learned, cooling is not uniform: The lower portion of the roof, where cool air is drawn into the system, stays as cool as the north side of the roof. Near the ridge, however, where hot air is exhausted, the vented roof is nearly as hot as the unvented roof.

Keep in mind that shingle manufacturers — even the ones whose products stand up well to heat — will deny warranty coverage to roofs built without code-prescribed venting.

Theory vs. Practice

Most venting studies assume a worst-case scenario. For instance, in Rose's experiments, relative humidity inside the test building is controlled at 50%. The result is that if the roof's venting system removes moist air from the house, the moisture is automatically replenished, providing in effect an unlimited source of moisture. Such a continuous moisture assault might occur in a house built over a wet basement or equipped with a humidifier that runs constantly, but isn't much like a typical house that dries out in the wintertime.

In the field, according to Rose, the houses with problems tend to be the ones that reflect this pessimistic assumption. "In a flat-ceiling, steep-roof attic, the only houses that have moisture problems are those where the attic is coupled to a wet space below," he explains. A connection between the attic and a wet crawlspace or basement is the problem Rose sees most frequently. In such cases, venting may not be able to remove all the moisture: "The moisture removal capacity of a fully vented roof assembly is limited," says Rose.

Nothing's perfect. On the other hand, researchers who speak of good performance in unvented roofs are usually talking about roofs built over perfectly airtight ceilings. Don Fugler, research director at the Canada Mortgage and Housing Corporation, thinks houses with ceilings tight enough to meet Canada's strict R-2000 standard "probably could get by without roof venting." But most Canadian houses, even new ones, don't have such perfect ceilings, and Fugler does not expect accepted venting rules to change. While building officials can easily see whether an attic has vents, he points out, measuring air leakage into the attic from the home requires an expensive blower-door test that building departments aren't equipped to run.

Bill Rose sees airtight ceilings as a more reliable way to ensure a dry attic than venting, and all his test roofs performed acceptably when the airtight ceilings were left intact. But uncapping the $1^1/_2$-inch ceiling hole — a small penetration compared with the kind of holes routinely made by plumbers and electricians — changed the picture: Correctly vented roofs worked best whenever there were ceiling penetrations.

The Real World

In practice, Bill Rose thinks most houses fall into a middle ground where venting balances moisture input: It's common for a family of four to generate about 13 pounds of moisture per day, he observes. "If you lose about 25% of that through the ceiling but have venting in place that can remove that amount of moisture, then you have a happy family."

This common outcome is the reason many experienced voices argue for staying with venting. For instance, roofing expert Wayne Tobiasson, a research engineer with the U.S. Army Corps of Engineers' Cold Regions Research Center in Hanover, N.H., says that the bulk of his field experience points one way: Ventilate the roof. He concedes that the code-required vent ratios may not be perfect, but notes, "Millions of houses have been built according to that rule and have performed beautifully."

In cold regions, moisture isn't the only reason to ventilate a roof, according to Tobiasson. "When there's a moisture problem in residential construction, there is almost always a massive movement of moist air. You first try to eliminate that source of moisture, then you provide a measure of venting to account for the real world."

But, says Tobiasson, "because of the monumental [problem of] ice damming, there is no question in my mind that the ventilated roof is an order of magnitude better in cold regions." Tobiasson has been called in on thousands of problem roofs in Army base housing. "Every time we find an unventilated roof, we ventilate it. That always solves the problem," he says. "We're batting a thousand." ■

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Roof-Venting Recommendations

When I started to research this article, a building consultant told me, "No building professional in his right mind would recommend violating accepted practice unless he had a very strong, case-specific reason." A close look at the research in the field bears out this conservative approach: No study to date has produced evidence strong enough to justify violating the building code.

However, venting today is trickier than in the past. Tight homes with humid interiors and lots of insulation run the risk of condensation in roof assemblies. If you build in a cold climate and you're following energy codes, you're probably building homes that are susceptible to moisture problems. To minimize the threat, here are some prudent steps:

- ***Stick to the building code.*** None of the research to date has convinced any code organization to change its venting rules — probably because most building departments have seen good results when the rules are followed. Using the code-recommended minimum as your starting point is your best bet.
- ***Keep it simple.*** Ventilated attics over flat ceilings tolerate moisture the best. When you get into cathedral ceilings or cape roofs, the risks increase.
- ***Balance your venting.*** Ridge vents tend to depressurize the roofing system. Allow enough low venting in the soffit to provide plenty of makeup air or your system may suck air out of the house instead of pulling in outside air. If makeup air is a problem, gable-end vents could be a better choice. Roof vent performance is heavily dependent on wind, and with vents in both gable ends, the wind will tend to push air in at one end and pull it out at the other.
- ***In cathedral roofs, provide a channel for air movement,*** not just an intake and outlet. The vent channel is critical: Leave a $1^1/_2$-inch air space between insulation and sheathing. Don't leave some rafter bays unvented, and avoid blocking rafter bays.
- ***Seal the boundary*** between the roof system and the living space carefully. Pay particular attention to penetrations like wiring chases, plumbing vent stacks, and recessed lights. Localized leaks can cause points of condensation and rot even in well-ventilated roofs. Also, beware of wet foundations: If a framing bay connects your attic to a damp cellar or crawlspace, all bets are off.
- ***Approach retrofits with caution.*** When you add attic insulation and venting to an existing building, you are changing three elements of the condensation equation at once. The vents allow moisture out of the attic, but can also depressurize the attic relative to the living space. The effect could be to pull more moist air out of the home. Adding insulation lowers the attic temperature, and the net result could be increased condensation in the attic.

— *T.C.*