Why Are Attics Insulated With Open-Cell Spray Foam So Damp?

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Learning objectives

Upon completion, participants will be able to:

- Design insulation details for an unvented conditioned attic that will prevent moisture problems.
- Recommend remedies to reduce the chance of sheathing rot in unvented attics with high moisture levels.
- Identify the sources of moisture in unvented conditioned attics with elevated indoor humidity levels.
- Decide whether open-cell spray foam or closed-cell spray foam is preferable when creating an unvented conditioned attic.

Credit

I'd like to credit Building Science Corporation for some of the illustrations used in this presentation.

The intersection of two topics

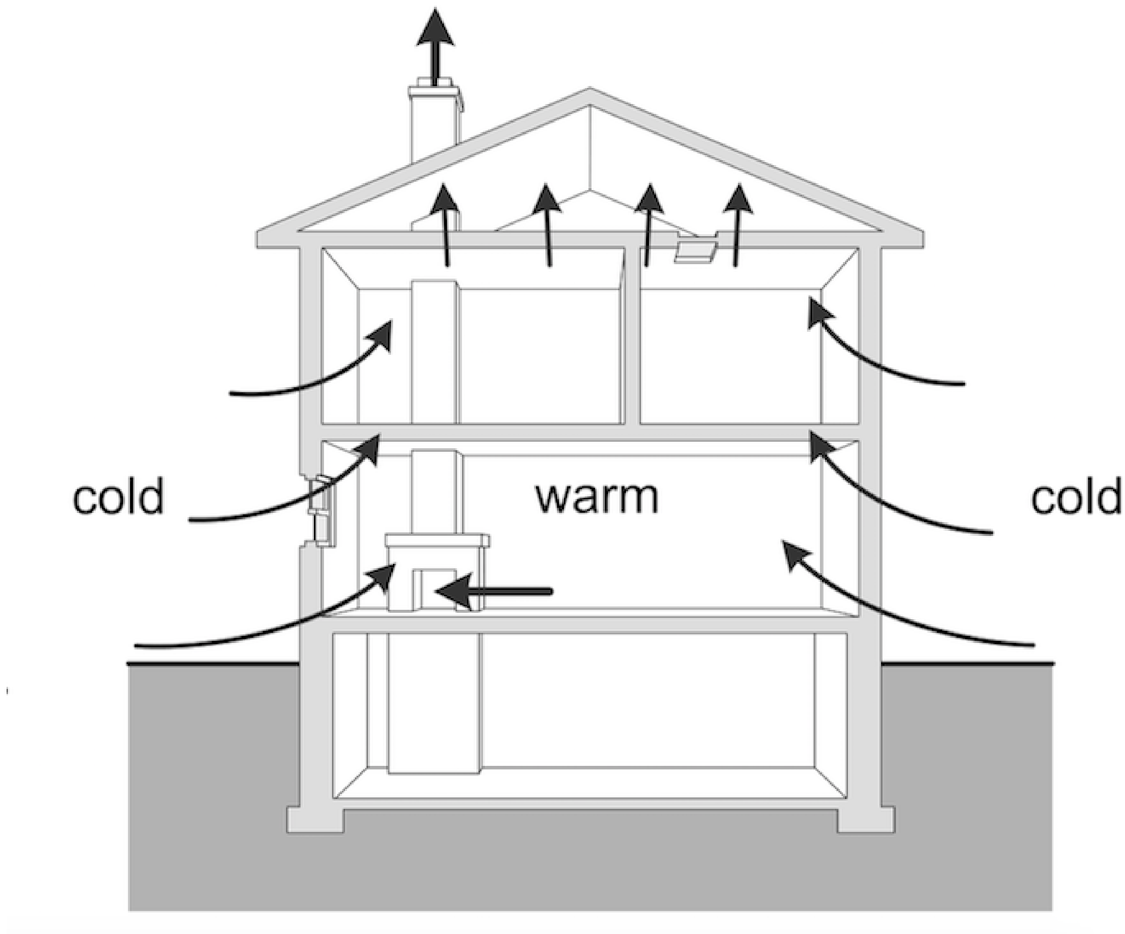
We're going to be talking about

- Attics and
- Spray foam

Attics

- In between spaces: neither inside nor outside
- Traditionally unconditioned, but increasingly conditioned.

Attics are complicated



Spray foam

Two basic kinds of spray polyurethane foam:

- **Open-cell** spray foam (1/2 lb. per cubic foot) is **vapor-permeable**.
- **Closed-cell** spray foam (2 lbs. per cubic foot) is more or less **vapor-impermeable**.

Both types of spray foam are **air barriers**.

Spray foam solves problems

Spray foam stops air leakage, unlike fiberglass

When attics are sealed, they turn damp

- Lots of homeowners are converting vented attics into sealed attics by installing open-cell spray foam on the underside of the roof sheathing.
- Once the work is complete, the homeowners often discover that their attic is damp.

Why are they damp?

Why? We don't know.

GBA readers report:

- "…higher than anticipated humidity in my attic…"
- "…very high humidity in the attic…"
- "The humidity shoots up into the 60s or 70s…"
- "I have a humidity problem in the attic…"
- "At the peak it's so damp that my glasses turn foggy…"

A key question

Where is the moisture coming from?

Find the moisture source

- Is it moisture from interior air?
- Is it moisture from exterior air?
- Could it be rain?
- Could it be dew?

For example, perhaps the moisture enters these attics in the summer through air leaks near the soffits.

Let’s back up…

First, some history.

EDU article, April 2005

Icynene dealers say,
"You don't need a vapor retarder."

Vapor Retarders and Icynene

The two major types of spray-in-place foam insulation — open-cell and closed-cell — are both excellent air barriers (see Figure 5). But some builders remain confused about vapor retarder requirements when using open-cell spray foam.

Installers of Icynene, the leading brand of open-cell spray foam, have been known to tell builders that their insulation can be installed without a vapor barrier, or even, in some cases, that the foam *is* a vapor barrier. For example, the following information can be found on the Web sites of Icynene installers:

- "Icynene foam insulation provides its own air infiltration protection and moisture control. Unlike common insulation materials, it does not need the protection of a polyethylene vapor retarder, building wraps, air tight electrical fittings, sticky tape or cases of caulking and cans of foam." (Web site of Environmental Foam of Vermont at *http://home.earthlink.net/~envirofoam/*.)

Figure 5. When Icynene is installed in a cold climate, the manufacturer recommends the installation of an interior vapor retarder. [Photo credit: Energy Smart Insulation]

EDU article, July 2005

Icynene insulation installed in Warren, Vermont is soaking wet.

Energy Design Update®

The Monthly Newsletter on Energy-Efficient Housing, from Aspen Publishers

Vol. 25, No. 7 July 2005

INDUSTRY NEWS

Every Failure Holds A Lesson

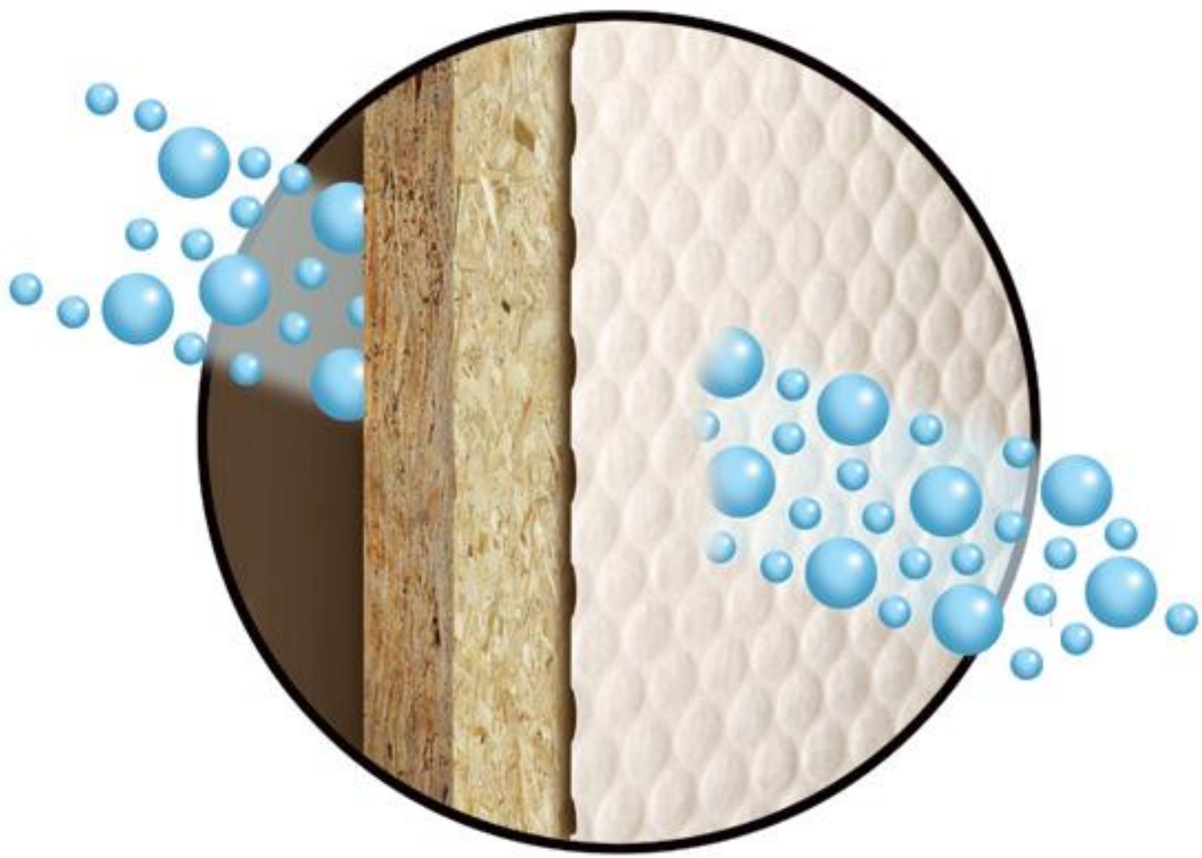
Less than two years after it was insulated with Icynene, a home in Vermont developed moisture problems so severe that the walls and ceilings had to be opened up in order to dispose of the saturated insulation. The case illustrates the importance of including a vapor retarder in cold-climate Icynene-insulated homes.

In the fall of 2002, homeowners Elizabeth and Matt Moffitt of Warren, Vermont, contracted with a licensed Icynene dealer, Nicholas Krywaka of Environmental Foam of Vermont, to insulate their small prefabricated home. The distributor who supplied the Moffitt house describes the uninsulated model purchased by the Moffitts as a "camping cabin" made by "Pennsylvania

Figure 1. Icynene insulation is an open-cell foam that allows water vapor to pass through it by diffusion. At the Moffitt house, the walls were so wet that water could be squeezed out of the sponge-like Icynene.

Confusion about diffusion

Some air barriers are vapor-permeable.



For example, canvas tents

Cold climate issues

- In cold climates, reports of damp sheathing date back 15 or more years.
- Open-cell spray foam is **vapor-permeable**, so the moisture in interior air often diffuses through the foam until it hits the cold sheathing.
- The solution to this problem (in theory) is to **install a vapor retarder** on the interior side of the insulation.

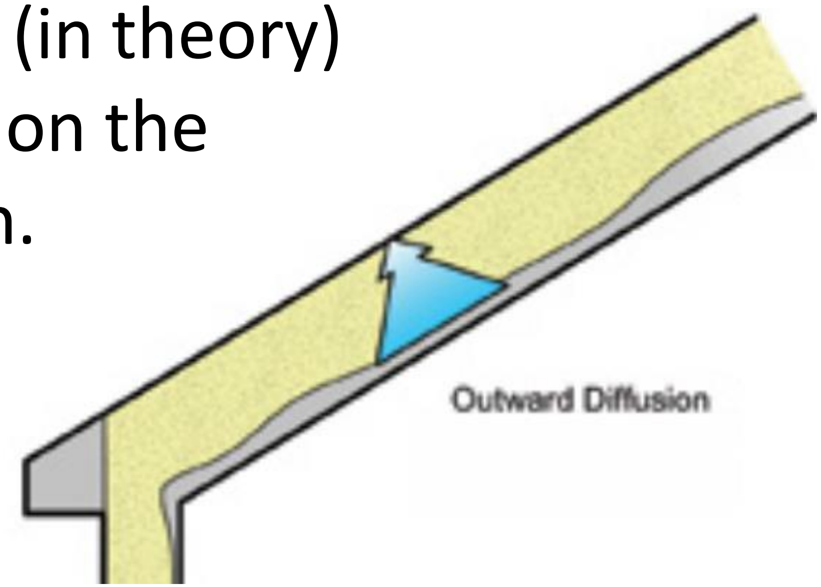


Illustration credit:
Building Science Corp.

Vapor-retarder paint won't work

For years, building scientists told builders to paint cured open-cell spray foam in attics with vapor-retarder paint.

The only problem with this advice is **it doesn't work**.

What’s new here…

Now, we’re getting reports of damp attics in **hot climates** as well as cold climates.

Why?

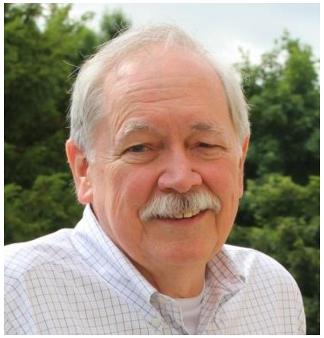
We don’t know.

Three experts

I interviewed:

- Joseph Lstiburek, Building Science Corp.

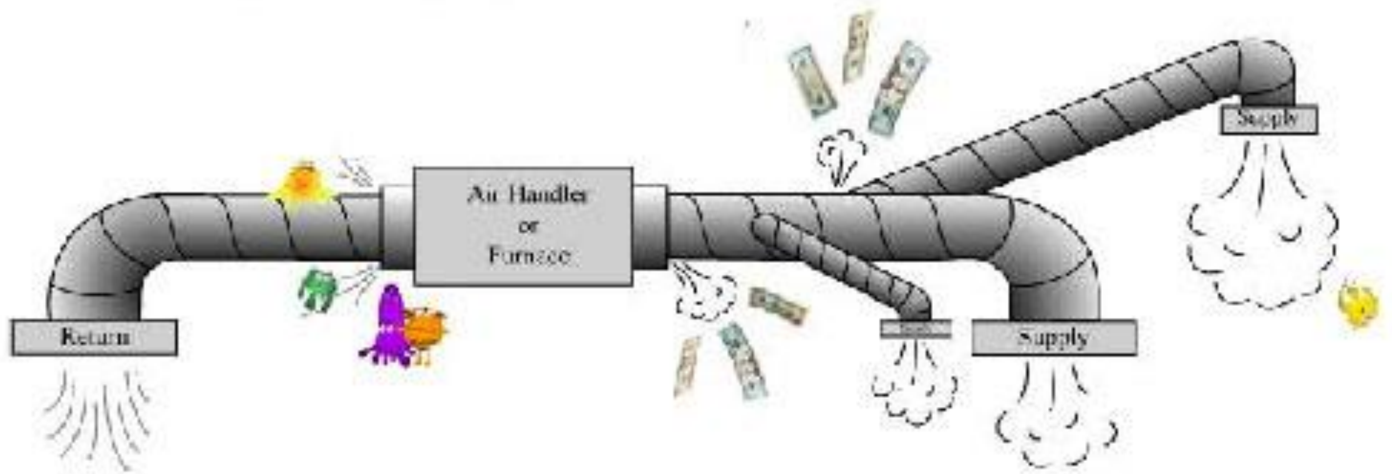
- William Rose, University of Illinois



- Iain Walker, Lawrence Berkeley National Lab.

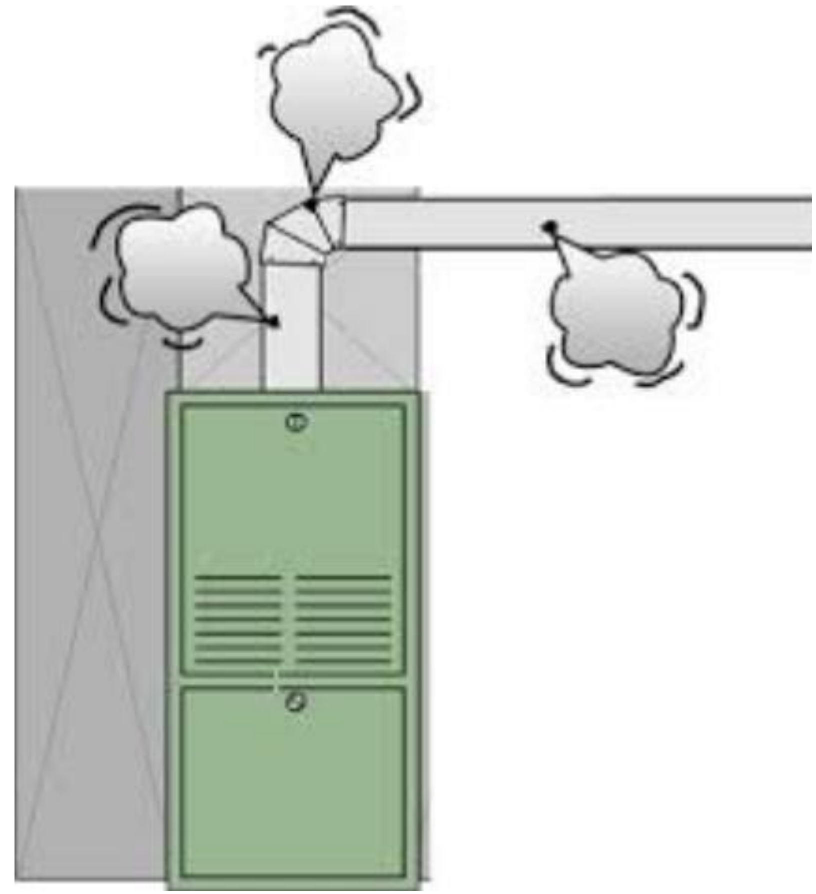
Joe Lstiburek: Some history

- “Icynene took this idea to Florida. We created conditioned attics with low-density open-cell foam. That approach became a huge industry in South Florida.”
- When these attics had leaky ductwork, everything was fine.
- “When ductwork got tighter, we ended up with very high humidity in the attics. We discovered sweating on the ducts and mold on the mastic.”



Leaky attic ductwork helps

Leaky ductwork helps protect OSB from getting too damp. If a builder installs leaky ductwork in a sealed attic, the roof sheathing will probably be dryer than it would be if the ducts were well sealed.



Leaky ductwork acts like an attic register

- Cool air in the summer and hot air during the winter was leaking out of the forced-air ductwork.
- While the leaks were unplanned, they helped condition the attic.
- Conditioned air is dryer than unconditioned air.

But why were these attics damp?

OK, leaky ducts helped.

But why were these attics damp in the first place?

Ping-pong moisture

Joe Lstiburek and Kohta Ueno started calling this attic moisture “ping-pong” moisture.

Is it inward solar vapor drive?

- An early explanation for the phenomenon of "ping pong" moisture was **inward solar vapor drive** through asphalt shingles.
- Lstiburek first championed, then abandoned, this explanation.

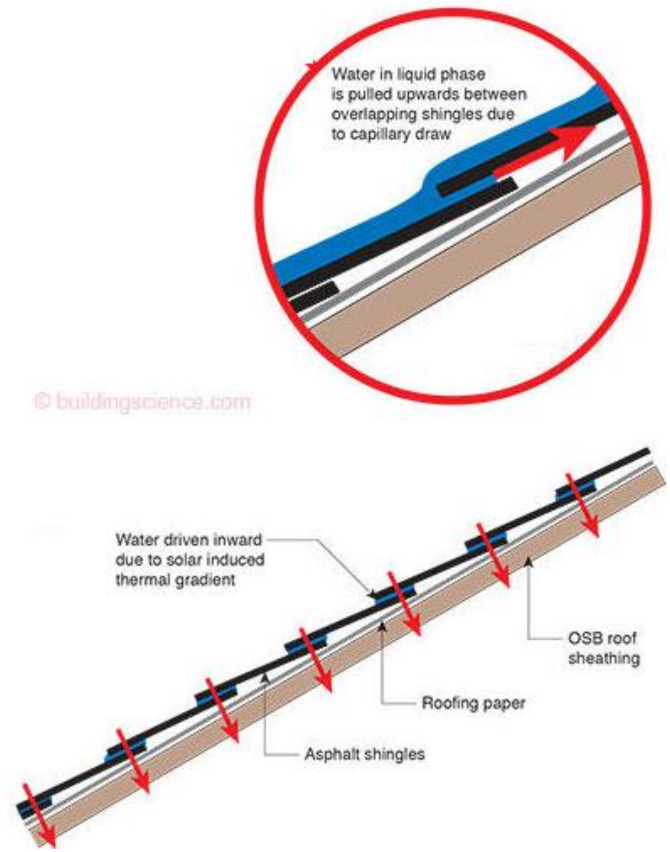
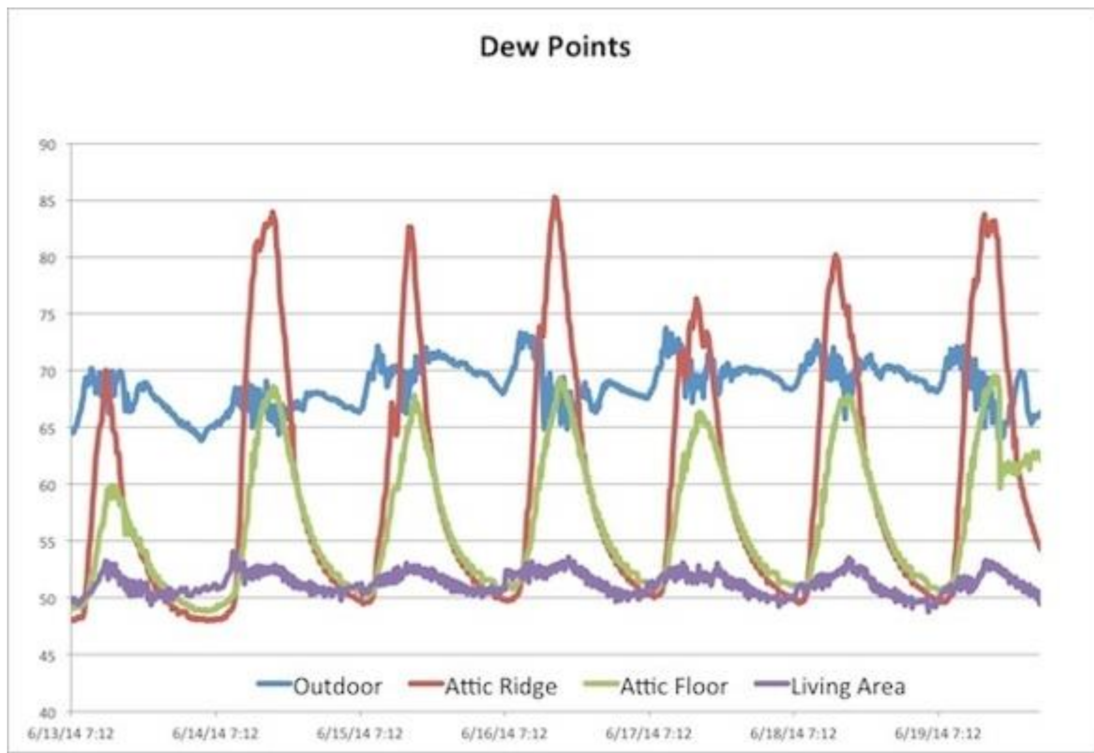


Illustration credit:
Building Science Corp.

The latest Lstiburek explanation

Lstiburek: “Moisture-laden air is lighter and less dense than dry air. Moisture-laden air ends up in the attic due to this ‘**hygric buoyancy**.’”



The moisture is stored in the sheathing and the foam

Lstiburek says that the moisture that causes these problems is stored in the roof sheathing and in the foam itself. (Because roof sheathing gets cold at night due to nighttime radiation cooling, it tends to absorb moisture every night.) When the sun comes out, the moisture stored in the sheathing is driven inward, and the attic air becomes damp.

Kohta Ueno: Mostly in the sheathing

Kohta Ueno wrote, “We are talking about the **moisture storage of the roof sheathing** as the dominant storage, not the foam itself. The foam storage is variable based on climate, elevation, and orientation, and tends to be small — smaller in hot climates, and larger in cold climates.”

Problems don't appear with closed-cell spray foam

Since **closed-cell spray foam is a vapor barrier**, it protects the roof sheathing from this diurnal cycle of moisture storage and inward vapor drive.

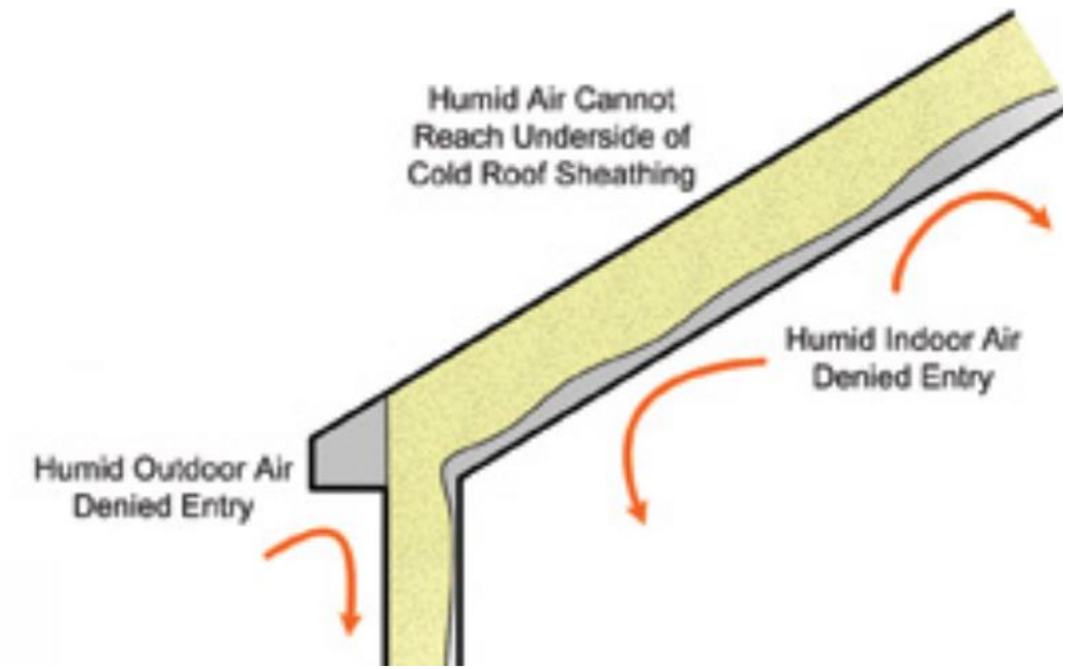
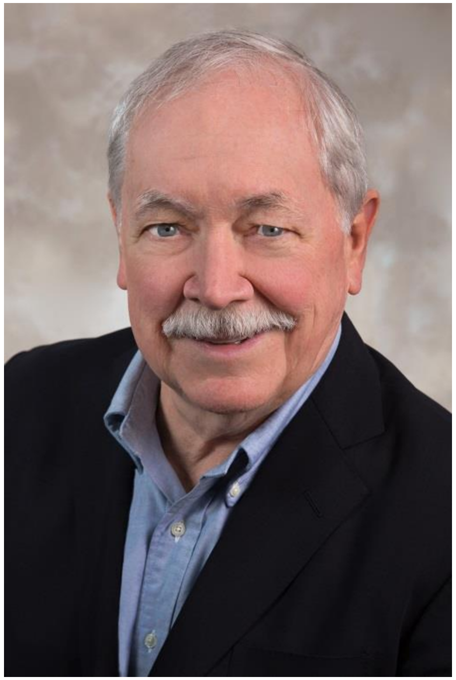


Illustration credit:
Building Science Corp.

Bill Rose disagrees



Bill Rose is a research architect at the Building Research Council at the University of Illinois:

"If we had a glass column as tall as a house, with a uniform temperature all around, then high school physics would perfectly explain the distribution of water molecules in that glass column. There won't be any stratification by molecular weight. … There is fairly uniform mixing. That's kinetic theory. That's how gas molecules behave. … **The final, equilibrium, long-term condition is always the mixed condition, with no stratification**."

Iain Walker

Iain Walker is a staff scientist at Lawrence Berkeley National Laboratory:

"The folks at Oak Ridge National Lab did some experiments with this type of attic four years ago. They did some careful measurements. They found that **indeed, it *is* humid in those attics. They are struggling to figure out why**."

Probably not ‘hygric buoyancy’

Iain Walker:

“Like Bill, I’m not convinced of Joe’s hygric buoyancy explanation. The answer probably has something to do with moisture going into and out of the wood and changes in temperature. The rates of the moisture going into the wood could be different from the rates of moisture coming out of the wood, allowing moisture to build up — a kind of ratcheting.”

A problem without an answer

Iain Walker:

“I don’t think we have the right explanation yet. This is a problem in building physics we don’t yet have an answer for.”

What about the spray foam industry?

Joe Lstiburek: “Now the spray foam people call me names. They are denying they have a problem, even though pretty much everyone knows this is a problem.”

“Open to ideas”

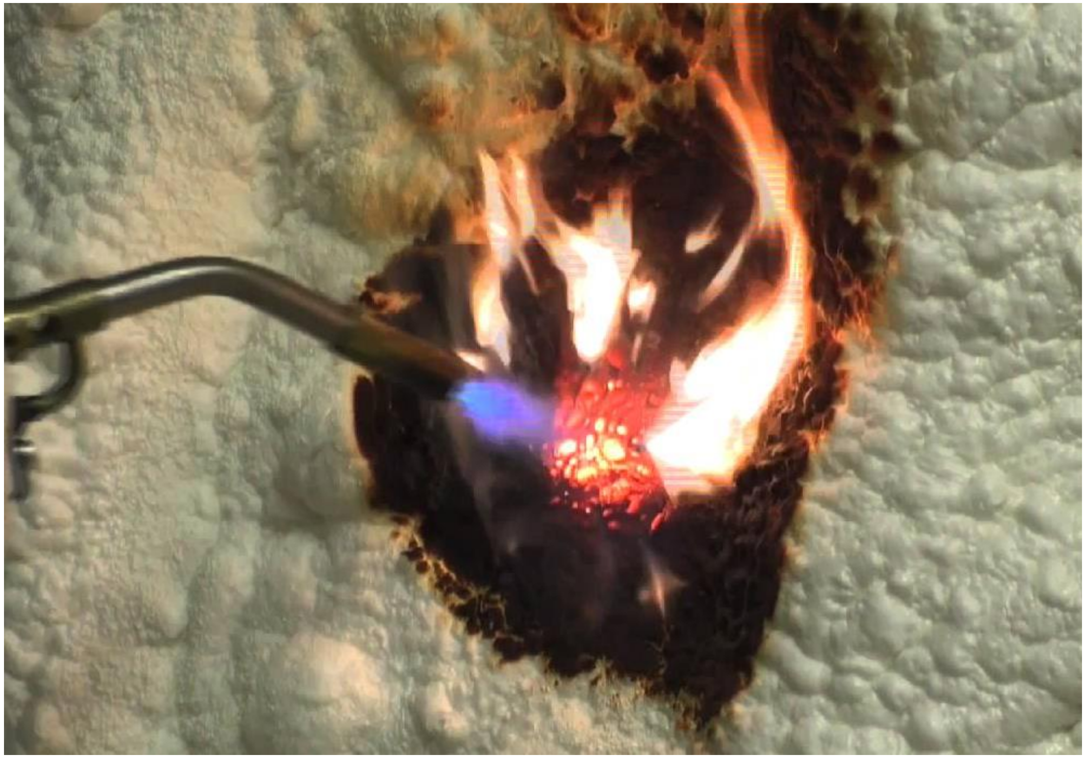
Rick Duncan, the technical director of the Spray Polyurethane Foam Alliance (SPFA):

“We’re not pooh-poohing the issue. We’re open to ideas.”

Code issues: Fire safety

Supply register plus return-air grille?

“Why not also require return air?” Lstiburek asked. “Well, we would need a code change. Without a code change, the fire people’s heads explode.”



Fire safety issues

- In most locations in a house, spray polyurethane foam — a flammable material — can't be left exposed. It must be covered by a **thermal barrier** — that is, 1/2-inch gypsum wallboard.
- Covering spray foam with drywall is expensive, and spray foam contractors want to keep prices as low as possible. The solution: install a less stringent barrier (an **ignition barrier**) to save money. The most common type of ignition barrier is a type of paint called an **intumescent coating**.
- So far, so good. If you want to avoid the expense of covering spray foam with drywall, the building code says you can — but only in a certain type of attic. An ignition barrier is permitted if there is no easy access to the attic; if the attic isn't used for storage; if the attic has no floor; and if the attic air doesn't communicate with the house air.

One possible solution: Cover the foam with drywall

Lstiburek:

“The assumption behind the approval of the use of intumescent coatings is that **air from the attic does not communicate with the rest of the building**. … None of the International Code Council Evaluation Service (ICC-ES) Evaluation Reports for spray foam insulations allow this type of application if there is ‘real’ air change or communication with the ‘occupied space.’ Unless, the spray foam is covered with gypsum board. **Cover the spray foam with gypsum board? Not going to happen**.”

Code violations in conditioned attics

Many conditioned attics include code violations.

Either:

1. The local code inspector is looking the other way, or
2. The local code inspector is unfamiliar with code requirements concerning ignition barriers.

Code says: No return ducts allowed

Return air ducts in this type of attic are technically **a code violation**, while supply air ducts are in a kind of legal gray area.

Change the code?

- Lstiburek is now lobbying for a proposed code change that would make it possible to provide supply air registers and return air grilles in this type of attic.
- In his article "Cool Hand Luke Meets Attics," Lstiburek wrote, "We can install a smoke detector in the return duct that is coupled to air handler and a fire alarm so that in the event of a fire the system is shut down. … **We need to codify this in the Model Codes**."

An explanation may not matter

- Designers and builders don’t really care about the ultimate resolution to this building science controversy.
- Designers and builders just want a strategy to prevent problems.

Advice for cold-climate builders

Cold-climate builders who use open-cell spray foam have to worry about outward vapor diffusion during the winter. In Climate Zone 5 and colder zones, water vapor in the indoor air can diffuse through open-cell spray foam installed on the underside of roof sheathing. During the winter, when the sheathing is cold, the sheathing will accumulate moisture.

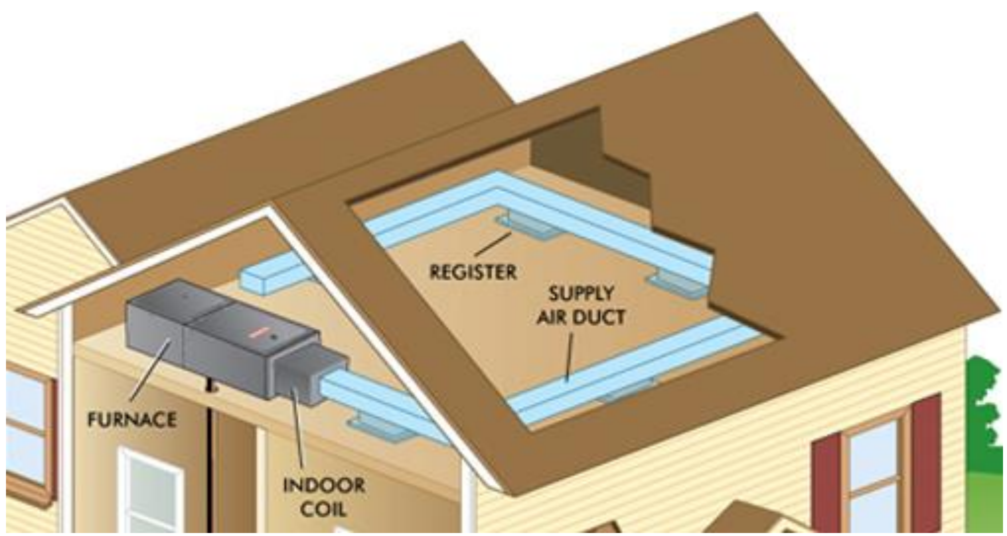
1. You need a vapor retarder

To prevent this type of risky moisture accumulation, cold-climate builders need to **install a vapor retarder** on the interior side of any open-cell spray foam installed on the underside of roof sheathing. Since vapor retarder paint won't work unless drywall is first installed on the interior side of the closed-cell spray foam — and since installing drywall is expensive — most cold-climate builders avoid the use of open-cell spray foam in attics. Instead, they install closed-cell spray foam.

2. You need a forced-air register

Lstiburek suggests that heating the attic during the winter, and air-conditioning the attic during the summer, can lower attic moisture levels.

"**Let's require 50 cfm of supply air from the HVAC system per 1,000 square foot of attic**."



3. You might need drywall over the foam

If there is access to the attic via a stairway, or if you use the conditioned attic for a purpose other than storage, you need a thermal barrier (1/2-inch drywall), not an ignition barrier like an intumescent coating.

Always provide a forced-air register

Lstiburek:

“You can use open-cell low-density foam in attics both north and south. But they have to be conditioned. Period. And in the north the open-cell low-density spray foam needs a vapor retarder.”

“Risky in all climate zones”

A research paper called “A Hygrothermal Risk Analysis Applied to Residential Unvented Attics” was authored by Simon Pallin, Manfred Kehrer, and William Miller.

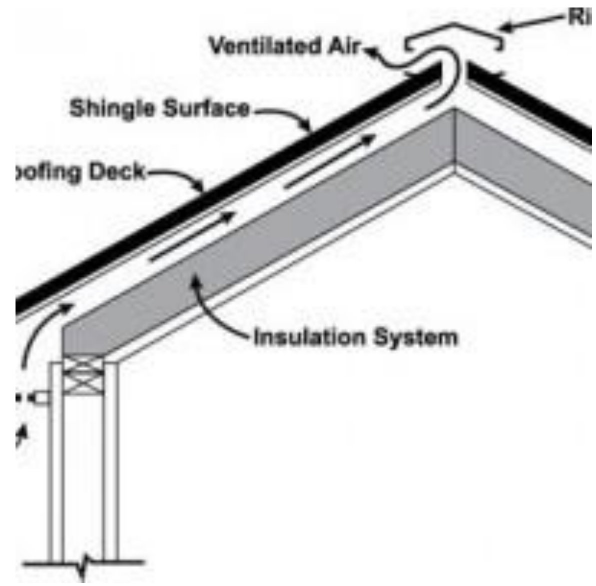
At a conference in Florida, Simon Pallin summed up the researchers’ findings this way: “Open-cell foam [in attics] is **risky in all climate zones**.”

Expensive and possibly illegal

While open-cell spray foam seems relatively inexpensive, its use on the underside of roof sheathing may require **a protective layer of 1/2-inch drywall**, an **interior vapor retarder**, and **special HVAC runs** to condition the air in the attic. Builders should consider these costs before specifying open-cell spray foam. One possible solution to the humid-attic problem is to install a forced-air supply register (and perhaps a return-air grille) in the attic. Note, however, that this solution violates the building code unless the spray foam is protected by a layer of drywall.

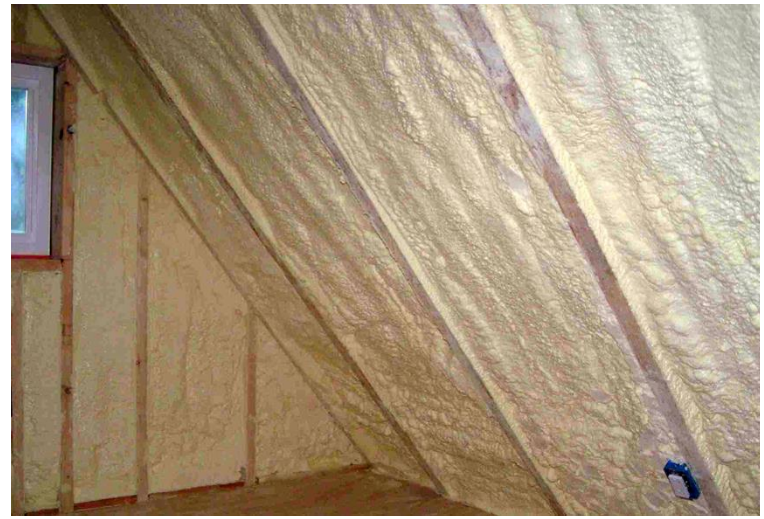
Ventilation above open-cell foam

If a roof has simple geometry allowing soffit-to-ridge venting, one way to reduce the risk of open-cell spray foam is to install **ventilation baffles** between the underside of the roof sheathing and the open-cell spray foam. This solution won't work, however, on a hip roof or a roof with valleys, dormers, or skylights.



Just use closed-cell spray foam

Considering the risks and hurdles I’ve described, I do not recommend the installation of open-cell spray foam on the underside of roof sheathing in any climate. In this location, **closed-cell spray foam is much less risky.**



Other ways to insulate sloped roof assemblies

- Build a vented assembly and use fluffy insulation
- Install rigid insulation above the roof sheathing
- Use SIPs or nailbase

Thanks

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