



Is using closed-cell foam worth the trade-offs?

BY MICHAEL MAINES

Closed-cell polyurethane spray foam is amazing stuff. It's a great insulator, with a higher R-value per inch than almost any other commonly available material. (Polyisocyanurate foam can be equivalent, but it varies with product and temperature.) When installed at least an inch or two thick, it essentially blocks water vapor and air movement. It even has some structural benefits: It's good at adhering sheathing to framing, and it also enhances racking resistance. Thanks to these qualities and more, including strong market-

ing from the industry, foam is only getting more popular. Unfortunately, it also has some serious issues that aren't typically discussed outside of green-building circles. Understanding these drawbacks may convince you to limit its use to those special situations in which it makes the most sense, or even to avoid it entirely.

Polyurethane foam starts as two containers of liquid chemicals, referred to as the "A" side (isocyanates, the primary component of the solid foam) and the "B" side (a blend of resins, catalysts, a blowing agent, a

flame retardant, and other compounds). When combined at installation, the chemicals react to create a polymer filled with tiny bubbles. The bubbles, or cells, are filled with a blowing agent and provide the insulating value, while the polymer forms the cell walls.

The ingredient that makes closed-cell foam special is the blowing agent—typically HFC245fa—but that's also its biggest drawback.

HFC245fa is a hydrofluorocarbon refrigerant and a persistent greenhouse gas; it goes up into the atmosphere and

stays there, preventing heat from escaping the earth. Carbon dioxide is commonly used as a measure of the damage a greenhouse gas can do, and HFC245fa is considered 1030 times worse than CO₂. The only common building product more potent is the blowing agent in conventional XPS rigid foam. According to the Environmental Protection Agency, "Although [HFCs] represent a small fraction of the current total volume of [greenhouse gas] emissions, their warming impact is very strong. HFC emissions are projected to

AT A GLANCE

CLOSED-CELL FOAM



INSULATING VALUE

Pro

- High R-value—the long-term thermal resistance (LTTR), which simulates how an insulation product will perform after five years, is R-6.0 to R-6.7 per in.

Con

- Though foam is often touted as performing at R-7.0 to R-7.5 per in., actual estimates for its R-value after 50 years are between R-5.0 and R-6.0 per in.
- Despite marketing materials that may claim otherwise, R-20 insulation properly installed in an airtight cavity will perform essentially the same, regardless of what the material is.

AIR-SEALING

Pro

- Blocks airflow at a thickness of 1 in., meets the definition of an air barrier, and is good for sealing some common sources of air leaks into a home.

Con

- A lot of air leakage occurs at transitions—between wall plates and floor sheathing, between doubled structural members, around door slabs and window sashes—where spray foam can't help.
- In rare cases, spray foam can pull away from the framing, usually because of installation issues, including a bad mix, low temperatures, or surfaces that are wet or contaminated, potentially leading to air

leaks, heat loss, and moisture accumulation.

ENVIRONMENTAL IMPACT

Pro

- Insulation saves energy and improves comfort, and foam is an excellent insulator.
- May be the best use for petroleum, compared to burning it for fuel or making throwaway bags and bottles.

Con

- Blowing agent HFC245fa is a powerful greenhouse gas, 1030 times worse than carbon dioxide. It enters the atmosphere and stays there, keeping heat from escaping.
- Foam of all types comes with high embodied carbon, the measure of everything it took to make the product.

VAPOR BLOCKING

Pro

- Effectively blocks water-vapor movement (Class II vapor retarder) when installed at a 1-in. to 1½-in. thickness (depending on the product), eliminating the need for an additional vapor retarder.
- The only option that meets building codes for unvented roof assemblies in cold climates—either installed between rafters, or on the building's exterior.
- Most straightforward and safest way to insulate existing foundations with a rough surface.

Con

- Roofs and walls in cold climates should be able to dry to the interior or exterior or both. Using a low-permeance material such as closed-cell foam can make that difficult in some assemblies.

SAFETY

Pro

- Most sources show no danger from off-gassing when the foam is properly cured.
- When installed foam meets code, fire retardants, intumescent coatings, or other ignition barriers and thermal barriers should keep foam from burning if the fire is caught in time.

Con

- Installation requires a full-body suit and a supplied-air respirator.
- May cause throat irritation and headaches if not cured properly, and even foam considered properly cured has an odor that sensitive people can detect.
- If a house fire is not extinguished quickly, the temperature (a little over 1000°F on average) is higher than the temperature foam needs to combust.
- Burning foam releases toxic gases, including isocyanates, carbon monoxide, nitrogen oxides, halogenated compounds, and hydrogen chloride.

STICKY AND STRUCTURAL

Pro

- Closely related to tenacious polyurethane adhesives, closed-cell foam has been shown in tests to improve the connection of sheathing to framing, which helps with racking resistance and keeping sheathing from pulling away from framing during high winds.

Con

- Compared to wood, foam is not particularly strong in compression and not strong at all in tension, so it does not substantially help assemblies resist perpendicular loads, such as snow loads on roofs or live loads on floors.
- You can't just pull foam out of framing cavities as you can with other types of insulation; whatever it touches is essentially ruined, making renovations more difficult.

EXPENSE

Pro

- Though more expensive than air-permeable insulation, foam doesn't require air and vapor controls, which drive down its relative cost.

Con

- At roughly \$1 per bd. ft., closed-cell foam may cost \$15,000 to \$30,000 to fully insulate an average house—about twice the cost of cellulose and four times the cost of fiberglass.

increase substantially over the next several decades if left unregulated” (from EPA Rule 21 Fact Sheet).

Some analyses have shown that the energy savings from closed-cell foam may never offset the environmental damage done. According to the technical director of the Spray Polyurethane Foam Alliance, Richard Duncan, PE, the blowing agent is 6% by weight of the foam. An average house with a basement that is fully insulated with spray foam may have 4000 lb. of foam to meet code in a cold climate. That means 240 lb. of blowing agent, equivalent to 250,000 lb. of CO₂. A tenth of that is released shortly after installation.

The emissions from any one project or even a lifetime of one builder’s projects may not make a measurable impact on the environment, but if a large portion of the building industry shifted away from products with potent greenhouse-gas emissions, it would make a big difference. Buildings account for up to 50% of greenhouse-gas emissions, the United States is responsible for more than 25% of that, and spray foam is one of the worst offenders in construction. In fact, the federal government has mandated that the HFC245fa blowing agent no longer be used in spray foam as of January 1, 2020.

Fortunately, there is already a more environmentally friendly option, a closed-cell foam that uses an HFO (hydrofluoro-olefin) blowing agent called Solstice, made by Honeywell, which is a much less potent greenhouse gas. Equivalent to carbon dioxide, it still has higher embodied carbon and is more damaging to the envi-

ronment than most nonfoam insulation, but it’s better than conventional closed-cell foam. Several brands and product lines of foam are now using this blowing agent, such as Lapolla Foamlok 2000 4G, Demilec HFO High-Lift and HFO Pro, Icynene ProSeal HFO, and Eco-Bay from BaySeal.

called ProSeal Eco. Its R-value (R-4.9 per in.) is lower than that of other closed-cell foams but higher than that of air-permeable insulation.

As for the polymer part of the foam, insulation may be the best use we have for petroleum, but it comes with high embodied carbon, the measure of what

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HFO-blown foam is not only better for the environment, but it has other benefits as well: Because of a lower-temperature chemical reaction, it can be safely installed in thicker lifts—up to 6½ in., depending on manufacturer, versus a maximum of 2 to 3 in. for conventional foam, which saves time. Field reports say that the cell structure appears more uniform than in conventional foam, meaning there’s a better chance of getting what you expect. Perhaps best of all, as the foam gets thicker, the R-value per inch increases to a larger degree than with other types of foam. HFO-blown foam costs more to purchase, but one installer I know said he was able to bring down his cost to the customer due to the labor savings.

Another environmentally friendly blowing agent, water, is typically used only in open-cell foam, but Icynene offers a water-blown closed-cell foam

it took to make the product. According to data from BuildingGreen, on a per-R-value basis, its embodied carbon is about twice as high as that of fiberglass, and 12 times more than cellulose. And because the chemical reaction to turn liquid resin into rigid foam is a sensitive one, things can go wrong. For example, an improper cure leaves an odor, which may cause health problems. I know of a few people who decided to rip out improperly cured foam, as well as others who live with the odor—under the promise that someday it will go away. Some types of foam are manufactured using soy derivatives and recycled content in place of some of the virgin petroleum resin, which is admirable, but the blowing agents have a much bigger impact on the carbon footprint.

Most insulation is nasty to work with to some degree, warranting personal protective

gear. But spray foam is in its own class; it’s the only one that requires a supplied-air respirator (no cartridge filter is capable of protecting against the fumes) and full-body suit to protect against short-term and cumulative health effects from the components in uncured foam. (Search “isocyanate exposure” for a long list.) Once foam is properly cured, most sources show no significant health risks. People who are sensitive to odors have told me that improperly cured foam causes headaches and throat irritation, and even foam considered properly cured has an odor that they can detect; however, no health concerns appear on material safety data sheets for properly cured foam.

Despite the drawbacks, I am not opposed to foam; sometimes the work-arounds to avoid it border on the ridiculous, even in the opinion of a dedicated tree hugger like me. There are things foam can do that other products simply can’t do. Installers seem to be slow to adopt HFO-blown foams, and even sustainably minded architects and builders I know did not realize it was on the market. (Start demanding it, and supply will react accordingly.) But in most situations on most projects, with an understanding of building codes and building science (and perhaps a bit of creativity), you should be able to find a system that insulates just as well (or better) than foam, with less expensive, more environmentally friendly, and more resilient materials.

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