Spray-Foam Problems

Hire trained applicators to ensure high performance and to avoid health issues

BY PAUL BENNETT

With superior air-sealing capability and manufacturer-claimed R-values as high as R-7 per in., spray polyurethane foam insulation (SPFI) has become common in high-performing new and remodeled homes. So why isn't spray foam always the go-to insulation? Cost is certainly a factor—spray foam is more expensive than fiber insulation—but there's another side to the issue. An internet search reveals nightmare anecdotes about lingering odors, having to excavate badly installed foam, and health issues attributed to improperly applied foam. Some of my work as an engineer has been investigating such failures and testifying about them in court.

Despite these stories, SPFI is installed correctly in thousands of homes each year, and failures are rare. One manufacturer, Icynene, claims over 350,000 successful installations in its 25 years. According to the Spray Polyurethane Foam Alliance, application errors are the most common causes of failure, and this is consistent with my own experience. General contractors should understand the complexity of SPFI and should know that the consequences can be significant when things go wrong. Removing SPFI after it has been installed requires a great deal of time and expense and in rare cases requires specialized subcontractors.

Photos facing page: Paul Bennett

Just what is spray foam?

Generally speaking, there are two types of SPFI: open cell and closed cell. Open-cell SPFI is fairly compressible, has an R-value of R-3 to R-5 per in., is liquid and vapor permeable because of its open-cell structure, and is less expensive than closed-cell foam. Closed-cell SPFI is rigid and has an R-value of R-6 to R-7 per in. With no open path through its cell structure, closed-cell SPFI can retard moisture-vapor transmission through walls and roofs. It is often chosen for this feature.

Both types of SPFI are comprised of two components that are mixed on-site. (There are single-component foams, but they're typically sold in aerosol cans for small air-sealing tasks.) Specialized skills on the part of the installer are required to feed the two components together into a mixing system that sprays and forms the SPFI. Component A is fairly standard across the industry and consists of monomers or prepolymers whose molecules end with reactive groups of isocyanates. Component B is more likely to vary among manufacturers but contains one or more polyols (which can be petroleum based or plant based) as well as proprietary blends of minor components, such as the blowing agents to promote foaming, a catalyst to accelerate the reaction, surfactants to control the consistency and foam cell size, a flame retardant, and coloring agents. Once the parts are mixed, a chemical reaction permanently combines, or "cures," the isocyanates and polyols into polyurethane during a rapid foaming process accompanied by a release of heat.

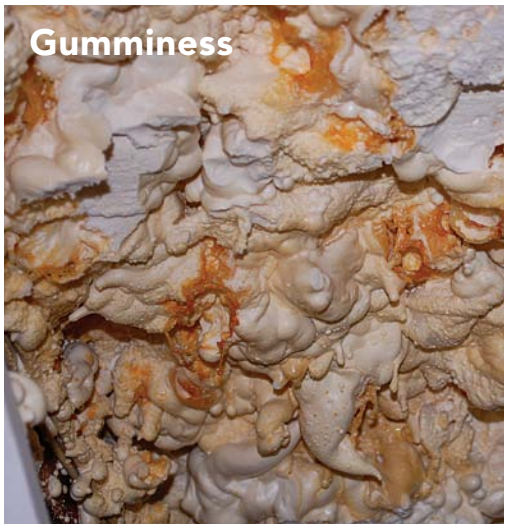
Properly applied and cured SPFI is a fine choice for most clients

Once fully cured, SPFI is reasonably benign. However, the unreacted chemicals in both components can be hazardous. Exposure to isocyanates in component A is a particular concern. OSHA has recently said, "Health effects of isocyanate exposure include irritation of skin and mucous membranes, chest tightness, and difficult breathing. Isocyanates include compounds classified as potential human carcinogens and known to cause cancer in animals. The main effects of hazardous exposures are occupational asthma and other lung problems, as well as irritation of the eyes, nose, throat, and skin."

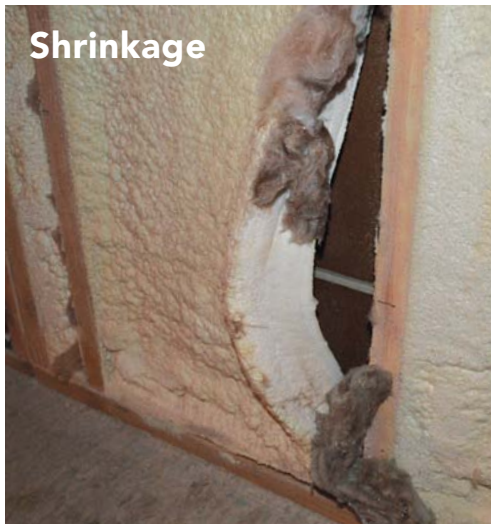
During and for a period of time right after an SPFI application, everyone in the building should wear respirators and disposable suits. According to the Center for the Polyurethane Industry, that means a "Type C supplied air respirator or self-contained

WHEN GOOD FOAM GOES BAD

In most cases, SPFI is a problem-free insulation that's nontoxic once cured. However, poor installation can lead to problems, some of which are obvious.



Gumminess is a typical sign of a B-rich mixture. If it looks like something a kid would want to eat (think caramel popcorn), then something has gone wrong.



Shrinkage within cells, and cracks or fissures in the SPFI, indicate an improper installation.

This B-rich foam didn't form correctly and has pulled away from the stud, providing a path for moist air to reach the sheathing.

breathing apparatus"—a step up from common half-face organic-cartridge respirators. Although other workers should be kept out of the building while it's being foamed, they can return to the work area after several hours if they're wearing the personal protective equipment recommended by the manufacturer. Homeowners and other individuals who don't need to be there should avoid the area for a day or more. Chemical-exposure risks for properly installed SPFI are limited, and they decrease with time. Once components A and B fully react, the risk of isocyanate exposure is essentially eliminated.

There are odors associated with foam installation. In any chemical system, including paint and floor finishes, volatile organic compounds (VOCs) may be released. Depending on the exposure duration, concentration, and frequency, VOCs can lead to headache, nausea, and irritation of the eye, nose, and throat. In extreme cases, VOC exposure can lead to organ and nerve damage. VOCs also can create an undesirable odor and affect nearby materials. The odors typically dissipate after a day, although VOCs may continue to off-gas at low levels for longer times. The nature and amount of the off-gassing depends on the particular foam, how it was installed, and the conditions in the home, including ventilation. Generally, a foam's normal off-gassing has been evaluated by its manufacturer, and VOCs remaining after days to weeks have been found to be below established levels of allowable exposure.

New spray foam is hot. *This IR camera shows the heat released from the foaming reaction. Applying foam too thickly can damage the product or even cause fire.*

Risks from improperly applied foam

If the ratio is off, unreacted components can remain. Any SPFI with off-ratio components needs removal. Although such SPFI can pose a higher risk of chemical exposure, particularly for people who have chemical sensitivities, removal is mostly necessary because off-ratio SPFI will not perform as intended. Depending on the severity of the problem, it may be necessary to media-blast and then seal the substrate to remove residue to prevent off-gassing.

In some instances, especially if the structure isn't properly ventilated, volatile amines or minimal amounts of aldehydes may linger, although these are typically below established permissible exposure limits and decrease with time. Amines can lead to unpleasant, fishy odors. According to the Centers for Disease Control and Prevention (CDC), short-term exposure to amines can irritate mucus membranes. Long-term exposure can even cause lung and kidney damage. Aldehydes can cause short-term effects similar to amines. Some have been classed as possible carcinogens. Again, health effects depend on the concentration, duration, and frequency of exposure.

Aldehydes are common in other building materials also, so foam insulation may not be the cause of these health effects. However, the increased tightness of a building from SPFI may concentrate preexisting aldehydes.

I don't think that chemical exposure risks are a reason to reject SPFI, but I can see why others might. As a civil engineer and general contractor, I recommend advising clients of the potential risks and to carefully weigh SPFI against its alternatives if you have a customer who is extremely health conscious or has a past history of respiratory problems. Previous exposure to some of the chemicals in SPFI, particularly the isocyanates, can sensitize people so that subsequent exposure causes severe reactions such as asthma. Consider hiring an industrial hygienist to test the indoor-air quality prior to allowing a high-risk client to reenter the structure.

Educate yourself, and supervise your foam contractor

Given the potential chemical exposures from improperly handled or applied SPFI,

Vapor permeance

A 2-in. lift of closed-cell foam typically provides a permeance rating of less than 1, which qualifies it as a Class II vapor retarder. When counting on SPFI as a vapor retarder, you might consider having samples of the finished product tested by a laboratory for permeance. I have seen cases where seemingly correctly applied closed-cell SPFI tested at permeance levels as high as 6. This can allow moisture vapor to enter framing cavities and condense, causing rot and other moisture damage.

Bottom photo, this page: Mark Parlee

Don't settle for a certified foreman who's rarely present or an inexperienced subcontractor who can't produce training certifications.

one might expect it to be tightly regulated. Indeed, many foam manufacturers sell only to trained contractors. However, I have seen spray rigs and foam components for sale online to anyone with the cash. Additionally, two-component foam kits typically used for smaller jobs such as insulating the rim joist of a house are readily available. Because of the problems that can arise with SPFI in the wrong hands, it should be used only by properly trained applicators who understand the potential health and property-damage risks associated with faulty application.

Builders rely on the expertise of subcontractors. For example, the average general contractor is not a licensed electrician or plumber. We hire qualified subcontractors and expect that we won't have to babysit them. With SPFI, however, I advise going beyond this usual standard and becoming educated on the foam that a subcontractor will use. Read the manufacturer's instructions and the product's ICC Evaluation Service Report so that you know the limits on lift thickness, shelf life, and temperature for storage and use. You may be surprised at the very narrow allowable ranges. For instance, Demilec says that its HeatLok Soy 200 Plus must be stored between 59°F and 77°F.

Don't settle for a certified foreman who's rarely present. Make sure the on-site applicators have received formal training. Be leery of an inexperienced subcontractor or one who can't produce training certifications. The Spray Polyurethane Foam Alliance offers lots of great resources. Its professional certification program is a good place to start when looking for a qualified subcontractor or simply to learn more about this product.

Maintain tight oversight of the subcontractor during the job. Learn to identify off-ratio SPFI and shrinkage. Specify that the subcontractor test for adhesion, density, and thickness to be sure that the finished product lives up to the manufacturer's promises. In some cases, the foam may appear to be properly applied and free of odors, but an incorrect application still may not provide the proper R-value and permeance.

Also, consider that older, leaky buildings will experience a dramatic drop in their air-exchange rate once sealed with foam, sometimes leading to complaints of new odors from preexisting materials. In such cases, an HRV or ERV may be warranted.

How spray foam goes bad

SPFI releases a lot of heat as it cures. If the application is too thick, the heat may not dissipate quickly enough, which can produce voids from burned cells. In extreme cases, structures where SPFI has been applied too thickly have caught fire. Manufacturers specify maximum lift thicknesses for this reason. For instance, Demilec says that its HeatLok Soy 200 Plus must be applied in layers not exceeding 2 in. and must be allowed to cure for at least 20 minutes between passes.

Low-temperature application can lead to off-gassing, inadequate vapor retardation and R-value, and decreased yield. Even if the drums are stored in a heated trailer and the job site is heated, what about the hose lying in the snow between the trailer and the building? The product could cool in the hose, producing an off-ratio or improperly reactive mix. Even if the drums, the hoses, and the building's air are all warm enough, the substrate might still be cold. SPFI that's sprayed onto a cold substrate is likely to produce immediate condensation. This can be a problem, because water reacts with isocyanates, throwing off the mix and changing the foaming behavior. In addition, unvented fuel-burning heaters can raise the humidity, increasing the chance of condensation.

Slightly off-ratio SPFI may not be visible, but a widely off-ratio mix is obvious. Foam that looks gummy, crisp, off-color, collapsed, or otherwise out of the ordinary should be removed. If large amounts of off-ratio foam are discovered, the integrity of any normal-looking foam nearby should be questioned, even if it looks fine to the naked eye. □

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Is spray foam green?

SPFI is often considered a green product because of its superior insulation and air-barrier properties. More open to question is whether SPFI can be called green based on sustainability and indoor-air-quality concerns. The use of naturally derived materials for component B, such as polyols based on soybean oil rather than petroleum, can also lead manufacturers to market a particular product as green. The greenness of the two types of polyols is subject to debate. What is not debatable is that the underlying chemical reaction to create the polyurethane is the same, and component A remains isocyanate based. Simply using plant-based polyols does not necessarily mean that the amount of VOCs or the risk of chemical exposure is reduced during installation.

Another concern is the blowing agents, which are mostly hydrofluorocarbons with a global-warming potential (GWP) hundreds of times greater than CO_2. Icynene has offered a water-blown version with a low GWP for years. Additionally, new hydrofluoroolefin blowing agents with a GWP about equal to CO_2 have entered the market. Several manufacturers, including Demilec and Lapolla Industries, are switching over to these agents.