Good Technical Practice

Troubleshooting and Repairing Problem SPF Applications

By Mason Knowles,
Mason Knowles Consulting LLC

How to identify and remove common defects in spray polyurethane foam application.

As a spray foam industry consultant, I'm often asked to inspect residential and commercial spray polyurethane foam (SPF) projects. Usually they're done correctly, providing effective insulation and air seals for interior and exterior walls, attics, basements and crawl spaces.

Sometimes I find problems such as off-ratio foam, poor substrate preparation, overspray problems, insufficient thickness and other errors. These can cause poor indoor air quality, increased potential for condensation in walls and poor energy performance.

This article discusses common SPF application defects, how to identify them and techniques to remove defective foam efficiently and safely.

Let's start with some basics.

Types of SPF

There are two types of spray foam for insulating building interiors: open-cell, or low-density "half-pound," SPF; and closed-cell, medium-density "2-pound," SPF. Each has specific properties that must be considered when specifying.

Each can be used as part of an effective air barrier system to help seal and tighten buildings against unwanted air infiltration and exfiltration [1].

Open-cell SPF weighs approximately 0.5 to 1.1 lb per cubic foot (pcf) of reacted material. It expands 100 to 150 times its

Evaluating projects before installation will help minimize design problems. Factors to consider include environment, climate, HVAC equipment, building function and anticipated occupant behavior. Photo courtesy of Demilec.

Quality foam requires the correct combination of heat, pressure and spray gun configuration. Photo courtesy of Demilec.

liquid volume to form a semi-rigid, non-structural foam plastic.

This foam has a mid-level R-value averaging 3.8 per inch. Its vapor permeance averages 35.5 perms at 1-inch thickness [1].

It typically has less than 10 percent closed-cell content. A good sound-absorber, open-cell SPF helps minimize sound transmission and structure-borne noise in buildings [1].

In colder climates, International Code Council (ICC) building codes require a vapor retarder on the warm-side-in-winter of open-cell SPF insulation [4].

Closed-cell SPF, typically used in insulation applications, weighs about 1.8 to 2.5 pcf of reacted material. It expands to approximately 30 times its original volume, forming a rigid, structural foam plastic.

The foam has a high R-value, averaging 6.5 per inch, and a permeance of 3 perms at 1-inch thickness [1]. The water-resistant foam is accepted by the Federal Emergency Management Agency as a severe flood zone-approved material [2].

With its relatively high flexible strength, it can enhance the structural qualities of some building assemblies such as OSB and plywood wall and roof assemblies [3].

While closed-cell SPF is considered a vapor retarder, its effectiveness depends on the climate and the insulation thickness. The colder the climate, the thicker the closed-cell SPF should be to minimize condensation potential. The 2009 and 2012 International Building Code and the International Residential Code (IBC Table 1405.3.1 and IRC Table R 601.3.1) specify the thickness of closed-cell SPF necessary to qualify as a vapor retarder in different climate zones.

A few manufacturers offer other spray foam materials that do not fit in the two categories detailed above. Described as "tweener" foams, they have densities averaging approximately 1 pcf and varying closed-cell and open-cell properties. Always consult with SPF industry experts, material manufacturers and building code officials to verify proposed SPFs are suitable for specific insulation projects.

Design

Even correct spray foam application can invite failure.

For example, the foam can be correctly applied, but in the wrong place, or at the wrong thickness. The design might include a vapor retarder it doesn't need, or it might be missing one that's required.

Make sure the design suits its purpose.

Possible design mistakes with SPF include —

- Incorrect SPF thickness for insulation efficiency and building code requirements.
- Lack of vapor retarders in cold climates where open-cell SPF is specified.
- Incorrectly sized HVAC — not taking into account that a better-sealed and insulated building may require less heating and air conditioning, and increase humidity within the building, which can increase potential for condensation in walls.
- Insufficient thickness for condensation control.

Evaluating projects before installation will help minimize design problems. Factors to consider include environment, climate (inside and out), HVAC equipment, building function and anticipated occupant behavior.

Hygrothermal modeling software such as WUFI or MOIST can determine the best type and thickness of insulation and where and what type of vapor retarders, ventilation and other moisture-control measures are needed.

The designer and the HVAC contractor should understand and estimate the air-sealing qualities of the foam to specify the correct type and size of HVAC equipment and ductwork.

Application Quality Control

Substrate Preparation. SPF can be installed on wood, concrete, metal, asphalt, foam sheathing and more. But the substrate must be clean and dry.

If the surface isn't clean, the foam won't adhere well.

Equipment

SPF installation depends on correct operation of the SPF equipment.

The equipment consists of two transfer pumps that send the liquid components to a proportioner. The proportioner heats and pressurizes the liquids, usually 120° to 140°F (49° to 60°C) and 800 to 1,400 psi.

Then the liquid components are sent in separate hoses to the spray gun.

Pulling the trigger allows the foam to enter the mixing chamber or nozzle, where it mixes and sprays the material onto a substrate.

Each equipment component must operate efficiently for correct installation. If one transfer pump stops, it can cause a crossover, clogging the spray gun and sometimes the whip hose with reacted foam, which stops the application.

If the heaters don't work effectively, the foam won't be hot enough to react properly.

If the spray gun is dirty, the foam will not mix well [5].

Quality foam requires the correct combination of heat, pressure and spray gun configuration, including the size of the mixing chamber, mix module and nozzle or pattern control disc. SPF suppliers provide data sheets with the range of temperatures, pressures and spray gun configuration. Varying these elements from instructions may result in a poor mix of foam that can cause problems:

- Poor adhesion, cell structure, shrinking and cracking.
- Low density and compressive strength in closed-cell SPF.
- Voids, fissures and cracks in the foam.
- Lingering odors [5].

Spray foam sticks to most surfaces and can drift long distances. Contractors should have overspray plans for each job, including masking and moving items away from the application [5].

Odor and Exposure Control

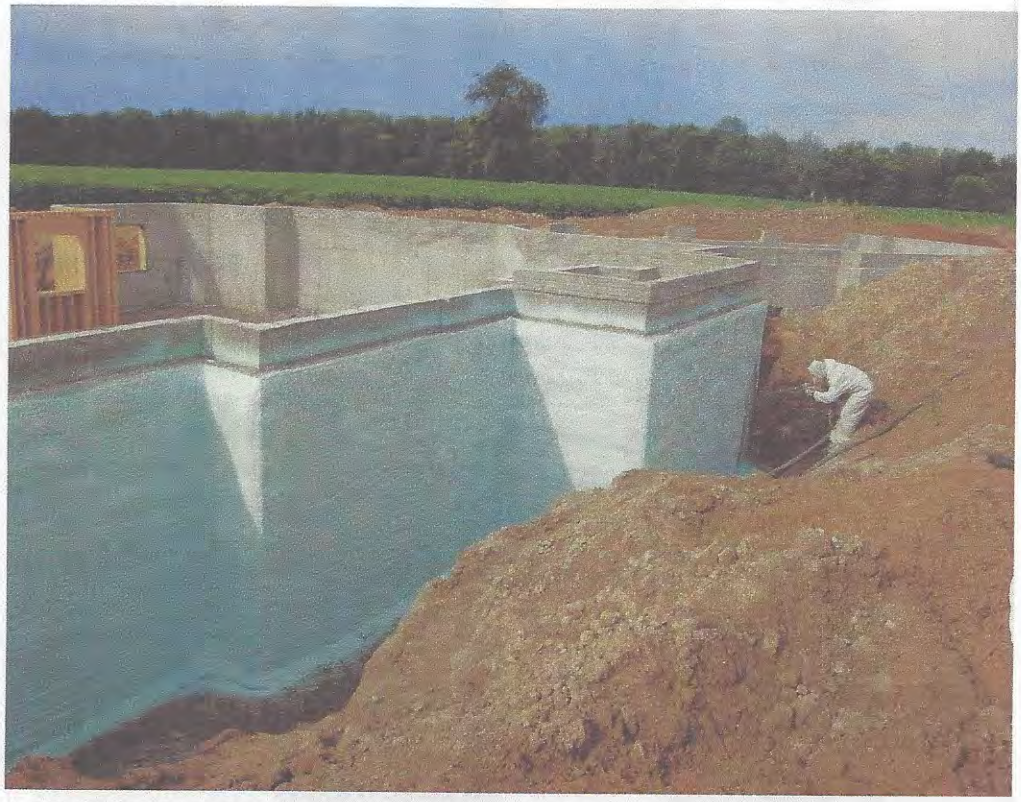
Application fumes and mists can harm installers and others nearby. Contractors should have specific safety plans for each job to keep fumes and mists from occupied areas, and to keep non-workers out of the application area.

Safety plans should include engineering controls, personal protective equipment for the SPF crew, protection of building occupants and trades, plus applicable government regulations.

Inspection

A professional trained on SPF building-envelope applications should inspect the completed spray foam application.

This can be a manufacturer's representative, owner's representative or third-party inspection company. On small jobs, where it is impractical to bring in a third-party inspector, another professional from your team or from the owner's staff typically performs the inspection. For large jobs, I recommend a third-party inspector.



Foam that is hard to remove and leaves bits of foam on the substrate is considered the best adhered. Here, SPF insulates a residential basement. Photo courtesy of Demilec.

Fumes and mists usually dissipate within a few hours to a few days depending on ventilation. Determine in advance how to ventilate the SPF area, and how long occupants should stay away [5].

Off-spec foam can emit odors much longer than usual. Contractors should inspect the foam periodically to make sure it is not emitting odors beyond what is expected [5].

SPF installations are important enough to building health that an extra set of objective eyes should always take a look, even when the installer is an expert.

Visit the Spray Polyurethane Foam Alliance's (SPFA's) website at sprayfoam.org or call 800-523-6154 for a list of accredited inspectors or certified field examiners.

Inspections of SPF applications include

both visual and physical inspection of the SPF. Inspectors use the manufacturer's technical data sheets, material safety data sheets, application instructions and specifications in the evaluation [6].

Evaluation reports include material suppliers, foam types and product numbers, lot numbers, specified thicknesses, photos, sketches of the areas to be sprayed and any other relevant information [6].

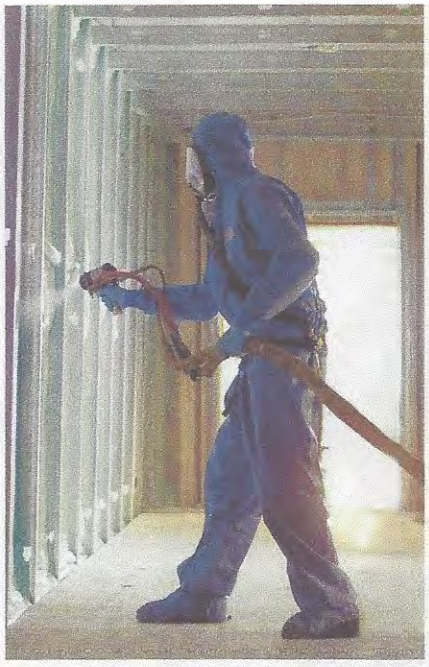
SPFA inspection criteria requires measuring and recording the minimum and average depth of the foam in representative areas to determine if the contractor met the minimum thickness requirements, and to evaluate the contractor's ability to uniformly install the SPF.

The criteria asks inspectors to identify and list quality issues including —

- Off-ratio or poorly mixed foam.
- Thickness below minimum requirements.
- Foam separation from target.
- Soft or hard spots in the foam.
- Color variations.
- Foam density irregularities.
- Compressive strength.
- Density uniformity.
- Compressive uniformity.
- Wet, cold or contaminated substrate.
- Surface profile and texture.
- Voids or gaps.
- Adhesion.
- Cell structure uniformity.
- Clean up of overspray or sloppy application. [6]

Uniformity of application. In my opinion, a good applicator can install closed-cell foam within a quarter-inch tolerance on a 2- to 3-inch-thick application in an open space. This means that the lowest point would be within a quarter-inch of the minimum specified thickness and no more than a quarter-inch higher (making for a half-inch total variation).

In confined spaces, such as between stud wall cavities, the variation is typically greater due to a thicker application against the studs. For example the interior of the wall or ceiling cavity ranges from 2.5 to 3 inches, while the foam against the studs would vary 3 to 3.5 inches.



SPF installations are important enough to building health that an extra set of objective eyes should always take a look, even when the installer is an expert. Photo courtesy of Demilec.

Open-cell SPF applications have greater thickness variations due to the greater expansion rate, usually 0.75- to 1-inch tolerance between stud wall cavities.

Testing compressive strength. If you suspect inadequate compressive strength, get a sample and measure with a field compressive-strength tester or pull-tester.

Typically a closed-cell SPF exhibits 20 to 30 psi and an open-cell SPF exhibits 2 to 5 psi. If the foam is softer or harder than this, it may indicate an off-ratio or poor mix.

Confirming adhesion. An inspector can usually verify good adhesion on closed-cell foam by randomly pounding the foam. Delaminated foam will have a hollow sound and compress slightly.

For more specific results, remove a sam-

SPF can be installed on wood, concrete, metal, asphalt, foam sheathing and more. But the substrate must be clean and dry. Photo courtesy of Honeywell.

Open-cell SPF is typically installed in one lift to a stud wall or ceiling cavity to full thickness. Start at the bottom and work up. Photo courtesy of Demilec.

ple with a coring tool, saw or knife.

Foam that is hard to remove and leaves bits of foam on the substrate is considered the best adhered. Also acceptable is a "mechanical bond," when foam leaves the substrate with some force but cleanly.

If it detaches easily, adhesion is poor and unacceptable [6].

Foam cell structure and quality. Foam should have a consistent cell structure without significant color changes, cell deformation or other anomalies. A dark or scorched area in the middle of the foam indicates high exothermic temperature, causing previously mentioned problems. [6]

Defect causes. Most problems with poor-quality foam applications are equipment-related. Other factors contributing to poor applications follow in decreasing order:

- Substrate preparation.
- Weather factors including excessive humidity or cold.
- Spray technique.
- Too thick or thin.
- Not enough time between lifts.
- Improper storage and handling.
- Wrong foam for the job.
- Material past its shelf life.
- Off-spec material. [6]

Foam Removal and Repair

A common remedy for defective SPF installation is partial or total removal. I've seen a wide range of tools and techniques for removing spray foam used with varying degrees of success. In choosing tools, consider the following:

- Type of foam and substrate.
- Type of defect — is it shrinking, cracking foam; off-ratio foam; or stinky foam?
- Tightness of space to move/work.
- Occupied or un-occupied building.
- Ventilation.

Closed-cell SPF Removal and Repair. Closed-cell SPF combines tenacious adhesion with exceptional strength-to-weight physical properties. While these properties can structurally enhance building assemblies, they make it hard to remove. I've found these tools and methods work well for removing closed-cell SPF.

Flat wall or ceiling with no studs

1. Cut the foam to the substrate using a reciprocating or keyhole saw in lengthwise grids approximately 2 feet (61-cm) apart. Cuts can be vertical or horizontal, depending on which way provides the best access and leverage.

2. Cut the foam at a 45-degree angle to the substrate in the center of a 2-foot grid.

Spray techniques for closed-cell SPF differ from those for open cell. The spray technique can affect the quality of the foam application. Photo courtesy of Demilec.

3. Force the blade of a spud bar or long-handled scraper at a low angle under the foam along the grid.

Pry the foam from the substrate with a push-broom motion.

You may need a pry bar to start. Be careful of the substrate.

4. Bag the foam pieces as they detach.

5. Use a paint scraper and wire brush to remove the remaining particles. In some cases you might need additional methods to clean the substrate and studs, such as sand- or cryo-blasting. Particularly around edges and protrusions, keyhole saw, paint scraper and pry bar are most effective.

Stud Wall

1. Use a keyhole or drywall saw to cut next to the studs to the substrate in each cavity. Be careful of wires and junction boxes.

2. Cut the foam at a 45-degree angle to the substrate in each stud.

3. Using a shorter spud bar or long-handled scraper, force the blade at a low angle under the foam between the studs. Use a push-broom motion to pry the foam from the substrate. You may need a pry bar to start. Be careful of the substrate.

4. Bag the foam pieces as they detach.

5. Use the paint scraper and wire brush to remove the remaining particles.

Repair

1. Prepare the substrate for new SPF.

2. Install the new SPF to specified thickness in a picture frame pattern and lift thicknesses of 0.5 to 1 inch for the first lift and no more than 1.5 inches for subsequent lifts. Wait 10 to 15 minutes between lifts or until the exothermic heat reaction has dissipated, or following the manufacturer's written instructions. Follow applicable industry-best practices, manufacturer's recommendations and government regulations.

Open-cell foam removal:

1. Cut a grid, similar to closed-cell foam, with a handsaw or long knife.

2. Remove the soft foam with a flat-edged shovel or long-handled scraper.

3. Use a wire brush or handheld scraper to remove small particles as needed.

Repair

1. Prepare the substrate for the new SPF.

2. Install the new SPF to its specified thickness in one pass following applicable industry best practices, manufacturer's recommendations and governmental regulations.

Personal Protective Equipment (PPE)

The Occupational Safety and Health Administration requires PPE, including respiratory protection, for removing defective foam. When the foam is cured and indoor air quality allows it, a high-efficiency particle dust mask with protective gloves and eye protection can be used.

For foam that is set up but emitting odors or is off-ratio, OSHA requires an air-purifying respirator, protective gloves and eye protection, unless the data dictates using air-supplied respirators.

For foam installed less than 24 hours, OSHA may require air-supplied respirators, protective gloves and skin and eye protection.

SPF manufacturers and trade associations such as SPFA are good sources of information for respirator selection.

Dust Containment

In my opinion, a conservative approach to foam removal should be taken to keep lightweight particles of foam from the rest of the building.

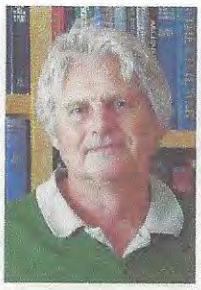
SPF is extremely lightweight and scatters easily during removal. To prevent this, separate the foamed area and seal air ducts and registers with tape and plastic.

Use a fan with a plastic tube connected to a filter outside the building to develop a negative pressure within the room that sucks in and traps airborne particles. Bag the removed foam, and vacuum the remaining small particles.

About the Author

Mason Knowles is president of Mason Knowles Consulting LLC, a consulting company specializing in troubleshooting problem SPF applications and providing technical information, education and training for the SPF industry.

Knowles is an SPFA-accredited building envelope and roofing inspector, SPFA-certified field examiner and SPFA certification exam preparatory course instructor. He chairs ASTM committees on SPF closed-cell insulation, SPF insulation guidelines and SPF roofing.



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