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Optimizing Foam Insulation

Developing the proper spray foam insulation strategy can improve the performance of your homes and reduce both energy and construction costs.

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In their efforts to increase energy efficiency, reduce air leakage, and improve home performance, more and more green building professionals are considering spray foam insulation options as part of their energy package.

Ask me what insulation I like best and I'll answer, "More." Ask a foam insulation contractor where to install foam and he'll say, "Everywhere." But the truth is, builders can *strategically* use the benefits of spray foam to improve home performance and reduce energy costs and the size of a home's HVAC equipment by optimizing the location and type of foam they choose. A builder's decision on whether or not to spec spray insulation should include an evaluation of the types of foam available and the ingredients used in their manufacture, as well as a focus on a home's air tightness and the "total R-value" of the home's walls, including framing.

The Options

There are two types of spray polyurethane foam (SPF) used in residential construction: closed-cell and open-cell. Closed-cell foams are denser than open-cell (1.8 to 2.0 pounds/cubic foot versus 0.4 to 0.6 pounds/cubic foot) and have higher R-values (typically R-6 to R-7 per inch for closed-cell foam versus R-3.5 to R-4 per inch for open-cell). Material composition also affects the moisture permeability of the product. Open-cell foams are vapor-open, with permeability in the range of 10 to 15 perms, while closed-cell foams have perm ratings below 1 perm. Closed-cell foam can also provide added structural strength when installed to manufacturers' specifications.

The three primary ways heat moves in and through building materials and assemblies are through conduction, convection, and radiation. Closed-cell spray foams help control the first two with their higher R-values. And both types of foam can reduce the main energy waster, air leakage, which can account for 30% to 40% of a home's heat loss or gain (depending on the climate zone, season, and local wind conditions).

While air sealing is one of the primary benefits of spray foam, however, we are consistently seeing other wall systems with well-detailed exterior air and water barriers and interior air barriers that are also performing very well. (See the chart on page 18 for total-wall R-values of a variety of insulation system types.)

Specifying a Cost-Effective System

The spray foam application strategy might seem obvious: Spray the stuff everywhere and the energy loads go down. That's basically true. But spraying it everywhere can be cost prohibitive and may be unnecessary.

The real benefit of foam is its ability to conform to irregular building shapes and to seal the cracks, gaps, and voids in the building envelope that waste the most energy. In homes using a foam system as the primary air barrier, it is possible to conduct a preliminary blower door test on a home prior to the installation of drywall, which may help builders trying to meet a performance target identify leaks. Before enclosing the insulated walls with drywall, a professional RESNET certified rater should perform a third-party insulation and air sealing inspection. At this time, a blower door test can be performed to assess the home's airtightness, and an infrared inspection (thermal imaging) can help identify any areas where insulation was missed.

While spray foam typically costs more than fiberglass or cellulose, spray foam can provide builders with time and cost savings by allowing them to identify problems and fix them before installing drywall.

TYPE OF CAVITY INSULATION AND WALL SYSTEM	TOTAL WALL R-VALUE, INCLUDING FRAMING
R-19 cavity insulation (fiberglass batts, perfectly installed)	14.42
R-19 cavity insulation (fiberglass batt, perfectly installed) and R-5 continuous exterior insulation	19.42
R-21 cavity (open-cell spray foam, complete fill)	15.05
R-23.5 blown cavity (high-density blown fiberglass)	15.77
Spray foam (2 inches, closed cell) with R-14 blown fiberglass cavity fill; total R-26.75 cavity	16.58
R-21 fiber blown cavity insulation and R-5 continuous exterior insulation	20.05
R-21 fiber blown cavity insulation and R-10 continuous exterior insulation	25.05

The chart lists the total R-values of a variety of insulation types in wood-framed wall systems including the framing elements without windows. You can see the impacts of framing materials on the total R-values for all types of wall systems, as well as the benefit of wrapping the exterior shell in rigid foam to reduce thermal bridging. Because insulation R-values only refer to cavities between framing members, it is important to think about total wall R-value. Note: All systems are 2 x 6 wall systems. Each assumes 23% of the wall area is framing. Total wall R-value includes framing, no windows, 1/2-inch drywall, OSB and air films.

Another popular use of spray foam has been to create conditioned attics that contain mechanical systems, ductwork, and other equipment. This is accomplished by spraying the foam directly to the underside of the roof deck, bringing the equipment and ducts into the conditioned space of the home. When done correctly, this method can significantly reduce air conditioning loads in summer. Ductwork must still be sealed, but any potential leaks are now inside a conditioned enclosure.

There is some debate about which type of foam works best in this application. The most common method in warm climates is to use open-cell foam because it allows for improved drying, with closed-cell the choice for cold climates because it provides some vapor control. There are many schools of thought on this; be sure to consider the physics of dew points, condensing surfaces, roofing type, and possibly even orientation.

An approach I am starting to see that better maximizes performance and cost is a hybrid approach, often called “flash and batt.” This technique relies on a thinner layer of SPF (1.5 to 2 inches thick) sprayed against the back side of the exterior sheathing, followed by fiberglass batts installed into the cavities to complete the insulation package. But batt insulation that is compressed or has gaps and voids does not work to its optimum performance level. The “flash” layer of foam creates an irregular surface in the wall cavity that forces the batt to be compressed in places, reducing the thermal effectiveness of the batt. To improve on this system, we recommend using blown-in cellulose or blown fiberglass to fill the void after foam has been installed, which will create a more uniform density and reliable R-value.

There are also new systems coming into the market that consist of a thin air-sealing foam compound that is sprayed around cavity perimeters and over framing and sheathing gaps in floors, walls, and ceilings to create a flexible air seal. After the gaps are sealed, the rest of the cavities can be insulated with traditional batts or sprayed fiberglass/cellulose products, providing a cost-effective option for reducing air leakage without getting into full spray foam installations. Both Owens Corning and Knauf offer these systems.

Material Considerations

One of the critical environmental issues with SPF products is in their manufacturing process, which relies on a fairly toxic blend of chemical ingredients. During manufacturing, these chemicals contribute to what is referred to as the Global Warming Potential of each product. SPFs are fairly high on this scale, and at the early stage of application they are more toxic to installers, who must take precautions to protect themselves during installation. Once the foams cure, they become mostly inert and basically non-toxic.

Some manufacturers are turning to soy-based content to help meet green performance goals, but the amount of soy content is still minimal compared to the rest of the chemical ingredients.

Applying foam insulation products takes skill. Careful attention must be paid to the proper amount of each chemical used in the mix, the system pressure, the moisture content of the substrates, and the temperature of each component prior to mixing at the nozzle. Finally, the desired thickness of the material must be monitored to make sure the recommended depth of each pass is being provided. Some foams need more time to cure and should be placed into the cavity in lifts. This will allow for proper expansion and cure time.

In high-performance homes, the benefits of spray foam often outweigh the negatives. While we don’t know much about the long-term performance of these newer spray foams, or how these products will affect deconstruction in the future, we do know that the continued development and use of new SPF construction products will offer significant benefits in the advancement of energy-efficient insulation technology.

Construction Instruction