The Wonderful World of Foam for Beginners

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Pat Dundon is the President of Dundon Insulation, Inc. He does business as "The Insulation Man" from a base in Binghamton, NY. His company has been spraying foam since 1993 in residential and light commercial applications. He also offers building science diagnostics, and his firm uses cellulose where it is applicable in his projects.

This article describes his personal experience with spray foam over the past 15 years, and it represents his opinion; it is not a scientific report or a technical evaluation. His objective in taking the time to compose this article is to share his personal experience over the past fifteen years. At the suggestion of Terry Brennan of Camroden Associates, Mark Bomberg, PhD, and Research Professor at Syracuse University agreed to review the article and make a few suggestions. We are deeply grateful to him. As Professor Bomberg mentioned to us, "I know a little bit about insulation."

The Building Performance Contractors Association of NYS is grateful to Pat for his willingness to share his experience. Questions about particular products should be addressed to manufacturers. Specific questions about applications should be referred to Code Officials or technical consultants. Many people feel—when it comes to spray foam insulation in Central NY--that Pat's opinions are well worth reading.

I'm going to try to give you an understanding of foam insulation: the good, the bad, and the ugly. I'll also explain the difference between open cell and closed cell, but first I'll discuss the things that are generic to all types of spray foam.

There are two primary categories of spray foam in the market today, urethane and urea formaldehyde. Urea formaldehyde was commonly installed in the 70's. It can be recognized as a white, fine-grain foam product that will become friable with minimal agitation. It is physically much like the foam florists use to keep cut flowers arranged in a pot, but it is white.

Urea Formaldehyde is applied by injection, and there are no mechanical controls or physical restrictions on the mix during installation. The installer depends on faith that what he is installing is what he thinks it is. Unfortunately, the product is not very tolerant of off-ratio mixing, and it often goes in off-ratio. This results in off-gassing formaldehyde and shrinkage. People think this product was outlawed decades ago, but it was not. UFFI, as it is often called, is still regularly used in commercial structures. The big box stores specify Urea Formaldehyde foam for application by injection in block walls. Lowes, Home Depot, Walmart, Sam's Club, Target, Circuit City, etc, all use this product.

Ratios

Urethane is a two-part system that is much more restrictive on ratio. If you do not deliver the components in the correct proportions, you get poor adhesion and you commonly get poor cell structure. Urethane is usually spray applied, not injected, so you can see what you are doing. Urethane application machinery uses a single-drive cylinder to push product through two material delivery cylinders. The delivery cylinders are of equal volume. It is pretty hard to get an off-ratio mix with urethane.

Density

For residential applications, urethane is usually marketed as "open cell" or

“closed cell,” “high density” or “low density,” “half pound” or “2 pound.” All of those terms refer to the density of the product, and each is somewhat vague. The density numbers used refer to the weight in pounds per cubic foot of material. The closed cell products typically hold refrigerant gas in their cells, and the open cells hold air. Of course it is the cells that provide the insulation value, just as it is the air trapped between the strands of fiberglass that makes that product work as an insulator.

There are also ‘water blown’ polyurethane foams. They can be found in both open cell and closed cell forms, but the blowing agent in both open cell and closed cell water blown foam is carbon dioxide and steam. In most respects the water blown foams are very similar to the other polyurethanes with one exception. Closed cell water blown foams have R values near R-5 per inch of thickness. Most water blown foams I have heard of or tried had problems with adhesion and reaction time. They drip a lot when they are applied, especially overhead, and they are hotter that most foams. What drips on an applicator will burn somewhat badly, so the applicators don’t like this product.

Closed cell foam at 3-pound density is used in commercial roofing, sprayed on top of the roof, and then covered with a spray-applied membrane. Higher density foams are also used for certain specialized applications.

Fire

As you read the materials that brought about fire protection standards for foam, you realize there is some bias on those committees. There are situations where foam is a fire hazard, and there are others where alternate insulation products use dangerous situations to inflate the risk.

A dangerous problem is that the building code allows Class 2 Foam (Flame Spread Rating 75). This material will burn like paper. Avoid it whenever you can, which is always if you work with 2 pound or less density foam inside the building envelope in today's market. The 3-pound density foams used in roofing outside the envelope are usually Class 2 foams. There are some firms that still manufacture Class 2 foam for the building envelope, and that product is less expensive than Class One foam, but the savings are very marginal and class 2 foam should be specified out.

Most foam used in residential work is “Class One” foam. This refers to fire and smoke ratings. Class one foam can be open or closed cell. It has a Flame Spread Rating of 25, and a Smoke Developed Rating of <450. Fiberglass products with FS 25 facings are allowed, in some codes, to be exposed to the inside of buildings, especially basements. Some people have construed this to mean that Class One foam can be left exposed. If you take a piece of Class One foam outside and light it with a torch, the fire will go out when you take the torch away. Some people are under the impression that foam will not burn because of that test. In both of these assumptions, THEY ARE WRONG!!! Foam will self-ignite at fairly low temperatures (I have heard both 450 °F and 700 °F). However, the thing to remember is that this is very low.

Foam is very good at holding in heat and stopping air movement. That is why it works so well as insulation. That is also why Class One foam is not safe if it is left exposed in a house. If a fire gets going in a building with foam insulation, the foam will hold the heat and smoke in very well. If the atmosphere in an attic reaches ignition temperature, the foam will self-ignite.

Previously, at least one open cell manufacturer marketed their product as not requiring a thermal barrier or ignition barrier. They have changed that now, and all open cell foams require an ignition barrier.

The Spray Polyurethane Foam Association is in the process of getting products tested to get allowances in the code to leave foam exposed in some applications. There is a big difference between insulating a structure from floor to ridge with foam and insulating only parts of the structure with foam. The fire problem is keyed on a complete envelope of foam holding the heat in. If we spray a basement wall, and the rest of the house is conventionally built with fiberglass, and you get a fire in the kitchen, how much risk is there that the basement will get to ignition temperature in under 15 minutes?

Ignition Barrier/Thermal Barrier

The codes that require a covering on foam require a “15 minute thermal barrier.” This material is supposed to prevent the foam from reaching ignition temperature for 15 minutes. Half-inch thick gypsum board has been proven to do that, as have coatings like Monocote, which is a spray

applied Cementitious product, and some cellulose products like K-13. (R 314.1.2 in the NYS code book, 2007 ed.) There is an exception in the code for "foam plastic insulation" applied in attics and crawl spaces "where there is access only for the service of mechanical devices." Section R314.2.3 in the 2007 NYS code book, 2007 edition, allows for the use of ignition barriers in place of thermal barriers.

There is a list of materials that are approved "ignition barriers" in that section of the code. Among them is 0.016-inch thick steel. The section also allows for the use of alternate products that perform as well as those listed. This has resulted in a market for "ignition barrier paints." These are intumescent products that delay the foam from igniting for a longer period of time than the steel. Some testing has shown those products outlast the steel by tenths of a second. I doubt that the steel holds heat out for very long.

It is odd to me that the code allows this lower grade substitution explicitly for rooms housing mechanical devices, but not for attics or crawl spaces with no access at all. I have my doubts that foam applied in a mechanical room with an ignition barrier is less dangerous with respect to fire than foam in a side attic that is fully enclosed with sheetrock and has no access.

Some of the intumescent (fire retardant paint) people are advertising their products as THERMAL barriers. If you read their data you find out these products are thermal barriers *if* they are applied to wood substrates. They have not been tested on foam, although the marketing says they are thermal barriers on foam. In fact, they are ignition barriers at best.

Off Gassing

I frequently get questions about off gassing from polyurethane foam. I have asked several people about this, product manufacturers and researchers have different approaches to this question. The researchers say the primary off gassing agent in any foam is the fire retardant. The fire retardants are irritants, they are not cancer causing, and they are not toxic, however, the EPA limits for off gassing of these materials are relatively high, and occasionally a customer will react to the levels that off gas from OPEN cell foam. My source says the closed cell foams don't off gas these materials as much as the open cell foams do. It is highly unlikely

that open cell foam will off gas for a long period after application. Manufacturers say any off gassing will drop below detectable levels within 30 days.

Most people who ask about off gassing are concerned with the closed cell foams. The logic is open cell foam is full of air, but closed cell foam has refrigerant in it. How much of the refrigerant can escape? The answer is most of the refrigerant that will escape from the foam matrix escapes during application. Once it is installed, the foams are very stable and, short of cutting the foam, there is little to no off gassing from closed cell foam.

<u>Comparison</u>

Low-density foam is commonly called half pound or open cell foam. Product manufacturers include Icynene, Demilec, and NCFI. There are also several soy based open cell foams.

Low-density foam (as a generic product) usually has a flame spread of 25, and a smoke-developed rating of <450. This means it can be called Class One foam. Low-density foam is effective in the retardation of air movement even though it does not have the mechanical properties of an air barrier. It typically has an R-value of 3.2 to 3.7 per inch as tested in a lab with a very good sample. In the field, cell structure controls R value. The closer you get to the show samples with consistent very fine cell structure the closer you get to R 3.2 to 3.7 per inch.

Low-density foam is not a Vapor Diffusion Retarder. It usually has a perm rating of 10 or higher. Researchers have cautioned that this high perm rating means open cell foam is a huge reservoir for moisture in the vapor form. They caution that open cell foam can become a sort of environment unto itself. It will hold water as vapor so the cells in the foam can have higher relative humidity than the inside air of the building. That means the foam itself can have a higher dew point and is at a higher risk of condensation. The low-density foam manufacturers have said the higher perm rating is an advantage because if water penetrates the roof surface, it will migrate through the foam and leave a telltale sign for the occupant. I had one incident where that happened, but it was not as clean as you would imagine. This was an extremely bad situation for any foam that involved a massive roof leak. What happened was, the foam held water for

about 3 years, until one year during the spring thaw the water from the roof was filling garbage cans at a rate of one an hour. The roof was shot.

Low-density foam manufacturers have secured Evaluation Services Reports or Legacy Reports through the ICC Labs that allow these products to be used with specific brand intumescents and vapor barrier paints to provide vapor and ignition protection. If you have ever tried to conform to a required millage thickness of a coating on a substrate, you will understand why some code officials are not inclined to accept the use of those products when they see the interior face of the open cell foam. It is easy to get a minimum thickness if you apply a coating to a flat glass surface. It is much harder to get a minimum thickness when the surface is irregular.

Low-density foam grows about 100 times liquid volume and cures in a few seconds. This makes it very hard to control the thickness during application. Most people overfill, and then shave off the foam. In that application process, voids in the foam are found and filled as the shaving is done. There is a potential problem in this process because, when the foam rises, it can float wires out beyond the stud faces and hide them inside the foam. Then, the shaver comes around and cuts them off. Foam shavings are usually discarded as construction debris.

Some Foam companies try to sell environmentalist customers on putting the foam shavings in an attic as you would use blown insulation. There are two problems with this, one is there is no known evaluation of what the R value of the shavings are. Another is this would require grinding the foam chunks into a chip form and distributing that in the attic. Foam holds static charge and it tends to cling to stuff like hoses or chippers to such an extent that the materials cannot be installed that way.

Some applicators are selling the product at an “average depth,” which means they are trying to avoid having to shave anything. In that situation, the voids in the foam are not usually found, and the applicator makes out well, but the foam is not going to perform as advertised with golf ball-sized holes in it.

The biggest inconsistency with open cell foam is that the samples you see from manufacturers at trade shows are always very fine grained, smooth, soft foam. What you see on the job is not usually like that. It has cells that vary from fine to pea size or larger, and the interior surface is not the

monolith you saw in the brochure; it is much more irregular. I had real trouble when we sprayed open cell because I had to set my customers' expectations at a level I could deliver, and from time to time I found I could not do that.

High-density foam is called closed cell, or 2-pound foam. Most closed cell foam you will find in the building envelope is also flame spread 25, smoke developed 450, but not all of it is.

The refrigerant gives closed cell foam higher R-ratings, Manufacturers commonly say R-6.8 per inch is an aged R value figure. Some researchers say this can be as low as R 6 per inch. As density of the closed cell increases beyond 2-pound foam, the R per inch decreases slightly. Applying closed cell foam too thick makes it too hot during application, resulting in more refrigerant escaping and lowering the R-value of the finished job. Most manufacturers recommend pass thickness of 3 inches or less. If you are specifying a roof it is best to use 2 inches per pass.

Until 2004, the refrigerant used in closed cell foam was HFC-141b. That gas contributed to ozone depletion and was outlawed by the EPA in 2004. Most foams now have 245FA as the blowing agent. This is sold by Honeywell under the trade name "Enovate" (http://www51.honeywell.com/sm/chemicals/enovate/).

There are other blowing agents on the market as well. They are all now required by law to be non-ozone depleting.

Closed cell foam adds rigidity to structures. It does not affect compressive strength, and it doesn't do much to enhance resistance to penetration, but it does add racking strength. This resists movement due to wind acting on the structure. This effective insulating material also makes occupants less aware of exterior conditions. The people think it is not as cold as it is outside, and they don't feel as cold inside.

Closed cell foam is an air barrier, and it is a vapor barrier in that it has a perm rating of less than 1 perm at 3 or more inches thick. It is not an acceptable vapor barrier in applications where the vapor drive is one direction all the time, like freezers, kilns, or some tanks.

It is an acceptable vapor diffusion retarder in cathedral ceilings. The Code

now allows the use of insulation materials that are less than one perm without roof ventilation in certain circumstances.

Closed cell foam is used occasionally in exterior basement applications. I have not done this, and some literature says insects will use the safety of a tunnel through the foam as an entry path to wood structures, so I discourage it.

There are both open and closed cell soy based foams in the market. These products use soy oil as a substitute for the petroleum in the foam. With respect to open and closed cell structures, they perform similiarly to any other open or closed cell foam. However, there is another variable here. There are various proportions of soy and petroleum in these products. All urethane foams are combinations of resin and isocyanate. The isocyanate side of any foam mix is nearly identical to any other foam. That means at least 50% of the foam installed in buildings by soy manufacturers is the same as the foam produced for building envelope use for the past 20 years by any foam manufacturer. I recently learned there are “greener” soy foams and there are less green soy foams. Some soy foam manufacturers are using both soy oil and recycled plastic in their resin; some use soy and virgin products. I have heard marketing jargon like this: “the resin is 15% soy oil and the rest is recyclables” or “60% renewable resource ingredients on the B side.”

Unfortunately, I do not know how to stop the spin here. These products do use soy oil and recycled content. That is good progress. However, the amount of soy and the amount of normal polyol is proprietary. How green they are, and which one is most green, is difficult, if not impossible, to determine. The market today encourages manufacturers to get as green as possible. Advances always include failures. When you are on the cutting edge, you occasionally get cut. This facet of the foam industry will grow. Contractors will continue to explore it to satisfy the requests of consumers. My practice is to try new products if we feel they are really going to work, but only to use products in which we find consistency.

We are presently using only a soy-based, closed cell Class One foam. We have found this product can be applied successfully in about 48 of the 52 weeks of the year. In extreme cold (<10 °F) or extreme heat (>90 °F) it is not really possible to do the work. Yields suffer in intense cold, and the product can froth out of the drum in intense heat. Still, 48 weeks out of 52

is better than most, and I really don't think people want to work when these foams don't work either.

I hope everyone has found this helpful. If you have any questions, feel free to email me, and I will try to answer them.

Additional Reading

For details on the restrictions for the use of UFFI (Urea Formaldehyde Foam Insulation) by the U.S. Consumer Product Safety Commission, see
http://www.cpsc.gov/cpscpub/prerel/prhtml82/82005.html

For information on the residual effects of this material in residences, see the report from Canada Mortgage and Housing Corporation:
http://www.cmhc-schl.gc.ca/en/co/maho/yohoyohe/inaiqu/inaiqu_008.cfm

Start here to learn about spray foam roofing:
http://www.sprayfoam.com/spps/ahpg.cfm?spgid=7

To help understand flame spread rating (ASTM E84 Test) and understand what the numbers mean:
http://www.acousticalsurfaces.com/soundproofing_tips/html/flame_spread.htm

Details about thermal and ignition barriers can be found in the ES Reports that are issued and updated by the ICC Evaluation Services Inc for a specific product. See a typical report here:
www.biobased.net/news/icc.pdf

The building department of Duluth, MN, has created a very useful flow chart that you may wish to look at:
www.ci.duluth.mn.us/city/bsafety/general/Spray%20Foam%20Plastic%20Insulation%20Requirements%202007.pdf
****The note on the flow chart about vapor retarders may or may not apply in your climate zone.**

Detailed discussion of vapor barriers and vapor retarders:
http://www.buildingscience.com/documents/digests/bsd-106-understanding-vapor-barriers/?topic=/buildingphysics/moisturecontrol/watervaporcontrolbasics/vaporpermeance/main_topic

For additional information about foam in all its forms:
http://www.foam-tech.com/

Online videos about spray foam products and other building components are available for free at
http://www.codecollegenetwork.com/video_center/

The first resource for anyone interested in applied building science is, of course,
www.buildingscience.com

On the lighter side of the Green Revolution, enjoy this:

http://www.metacafe.com/watch/1319940/start_using_reusable_shopping_bags_and_stop_using_plastic/