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Maximum Thickness Restrictions For Spray Foam

Most contractors and building inspectors appear to be unaware that the technical specifications for spray polyurethane foam (SPF) products often include "maximum thickness" limitations. Since buildings insulated with the listed "maximum thickness" of spray foam often fail to meet minimum prescriptive R-value requirements, builders who learn of these limitations are often surprised and confused.

The "maximum thickness" confusion is complicated by the fact that product specifications often list two different limitations on foam thickness: a maximum thickness per pass during installation of the spray foam, and a maximum cured-foam thickness arising from code-mandated flame-spread tests.

"Maximum Thickness" May Be Only 2 Inches

To prove to local building officials that spray foam meets code requirements, most SPF manufacturers have had their products evaluated by the International Code Council Evaluation Service (ICC-ES). After conducting a product evaluation, ICC-ES employees summarize their findings in an Evaluation Service Report (ESR). Although these ESRs often convince local building officials to approve the use of spray foam, they have increased rather than reduced confusion over "maximum thickness" limitations.

The uncertainties over the meaning of maximum thickness limitations were highlighted in a public letter from John Hogan, the senior code development analyst for the Seattle Department of Planning and Development. In his January 23, 2007 letter to the ICC-ES Evaluation Committee, Hogan noted: "The ICC-ES reports specify maximum thicknesses for the products ranging from:

- 6 inches maximum in ESR-1383 (BioBased 501),
- 2 inches maximum in ESR-1615 (Insulstar),
- 6 inches maximum in ESR-1172 (Sealection 500), but only 3.5 inches maximum for attic walls,
- 5.5 inches maximum in NER-420 (Icynene), but 6 inches in certain attic constructions,
- 2 inches maximum in ER-3974 (Froth-Pak)."

Hogan continued, "It is worth noting that, in the IECC and the energy chapter of the IRC, the attic insulation requirements for all climate zones are never less than R-30 and in the colder climates reach R-38 and R-49. Consequently, none of these spray foam insulation products would comply with the prescriptive requirements for attic insulation when used individually. Further, the wall insulation requirements for the colder climate zones are R-19 or R-21. Consequently, some of these spray foam insulation products would also not comply with the prescriptive requirements for wall insulation when used individually."

"Maximum Thickness" Is Still Too Thin

Maximum thickness limitations can be found not only in Evaluation Service Reports, but also in manufacturers' specifications for SPF products. Most of these limitations are written in such a way that they raise more questions than they settle (see "Maximum Thickness Limitations For Cured Foam"). Among the unanswered questions: "How can builders use spray foam when prescriptive code requirements call for insulation with an R-value that exceeds the 'maximum thickness' listed in manufacturers' documents?"

According to James Andersen, the manager for applications and training at BASF, a spray foam manufacturer, "If we have a requirement for R-38 in a cathedral ceil-

ing, we would calculate an R-value of approximately 6 per inch, so we would need 6.3 inches of foam." Unfortunately, however, BASF specifications note that "typical installations" of BASF Comfort Foam 158 "are limited to a total thickness of 4 inches." Such limitations raise obvious hurdles for builders who hope to receive approval for thicker installations of spray foam.

According to Hogan, who provides technical assistance to Seattle's building inspectors, foam manufacturers provide varying responses to questions about maximum thickness limitations. "In Seattle, virtually all of the residential plans show fiberglass insulation," Hogan told ***EDU***. "When the builder wants to change the insulation to spray foam, the inspectors haven't had the ability to assess these foams, which are all different. The inspectors are relying on the ICC-ES reports. When I reviewed the reports, I thought they were done in an inconsistent manner. From some of these reports, it looks like you can only spray the foam to a thickness of 5 or 6 inches, which doesn't achieve R-38. When the manufacturers are contacted, some have said, 'That's true,' acknowledging what's written in the ICC-ES Reports. But other manufacturers say that the limitation just means that 5 or 6 inches is the maximum that can be installed in one swipe."

Inspector and Builder Confusion

Questions arising from maximum thickness limitations pop up periodically on online bulletin boards. On a Web forum maintained by *www.sprayfoam.com*, poster Dick Russell asks, "On reading the codes, as well as past posts here, it seems that the code allows only the thickness that has been tested, but the test facilities can't handle more than 4-inch thickness. The question remains as to how to obtain code-required R-values or superinsulation levels if thickness is restricted, unless hybrid walls/ceiling installations are done (foam plus cellulose). The most common remark I have seen is to check with the local AHJ [authority having jurisdiction] to see what he will accept."

Ed Price (North Logan, Utah) posted a similar message at the Web forum maintained by the International Code Council: "Another issue we have with the product [one type of spray polyurethane foam] that has not been resolved to our satisfaction yet is the fact that the evaluation report allows this product to be applied with a maximum thickness of 5.5 inches (a nominal 6 inches is allowed in attics and crawlspaces). The report gives an R-value of 5.7 for the 1.6-inch-thick test sample. We don't see how an adequate R-value can be provided in attics for our area. The company claims that there is an alternate way to evaluate the insulation value provided by their product, but they have not provided us with any documentation for that claim yet."

A writer using the nickname "Z-Builder" responded, "Some inspectors also know that the maximum depth allowable of the spray foam in an attic is 6 inches. This is fine for areas where R-21 or less is required, but if the area requires a higher R-value than 21, the testing approvals won't allow it."

Maximum Thickness Limitations For Cured Foam

Maximum thickness limitations for cured spray polyurethane foam can be found in reports from ICC-ES, as well as in technical specifications from spray foam manufacturers.

According to the ICC-ES report for BioBased 501 (ESR-1383, issued January 1, 2006), "BioBased 501 spray foam insulation, at a maximum thickness of 6 inches and a nominal density of 0.5 pcf, has a flame-spread index not exceeding 25 and a smoke-developed index not exceeding 450 when tested in accordance with ASTM E84." BioBased 501 has an R-value of 3.25 per inch, so the maximum thickness of 6 inches yields an R-value of about 19.5.

The ICC-ES report for Home Foam Insulthane 100 (ESR-2360, issued September 1, 2007) lists a similar maximum thickness: "The insulation, at a maximum thickness of 5 ½ inches and a minimum density of 0.43 pcf, has a flame-spread index of not more than 75 and a smoke-developed index of not more than 450 when tested in accordance with ASTM E84." Since Insulthane 100 has an R-value of 3.23 per inch, the maximum thickness of 5 ½ inches yields an R-value of about 17.8.

The ICC-ES report for Insulstar spray foam from NCFI (ESR-1615, issued February 1, 2005) lists a maximum thickness of only 2 inches: "Insulstar Spray Foam Insulation is a spray-applied, semi-rigid, cellular polyurethane foam plastic insulation having a maximum thickness of 2 inches and a nominal density of 2.0 pcf." Insulstar has an R-value of 5.77 per inch, so the maximum thickness of 2 inches yields an R-value of about 11.5.

The specifications for a closed-cell foam from BASF, Comfort Foam 158, advise installers, "Comfort Foam 158 is designed for an application rate of ½ inch minimum to 2 inches maximum. Once installed material has cooled it is possible to add additional applications in order to increase the overall installed thickness of SPF. Typical installations are limited to a total thickness of 4 inches." Since Comfort Foam 158 has an R-value of 6.2 per inch, the maximum thickness of 4 inches yields an R-value of about 24.8.

Figure 3. The specifications for most spray polyurethane foams include maximum thickness limitations. To obtain approval for thicker foam installations, a manufacturer must conduct full-scale testing of the foam's flame-spread and smoke characteristics. [Photo credit: BASF Polyurethane Foam Enterprises]

Mike Winkler, a building official in Holland, Michigan, posted a comment on the topic under his online nickname, "DaddyDog": "None of the spray foam products I have seen are approved to be applied thicker than 5.5 inches and that will not provide the required minimum R-values for northern states such as mine. Of course the foam people want you to believe their product is magic and the laws of physics do not apply to their product."

Blame It On the Tunnel Test

Spray foam manufacturers explain that maximum thickness limitations are the result of a code-required smoke and flame-spread test, ASTM E84. (A requirement for ASTM E84 testing can be found in section R316.1 of the International Residential Code. ASTM E84 testing is also required for foam insulation products by ICC-ES document AC 12, "Acceptance Criteria for Foam Plastic Insulation.")

The ASTM E84 test, "Standard Test Method for Surface Burning Characteristics of Building Materials," is a prescriptive material test; according to ASTM, "The purpose of this test method is to determine the relative burning behavior of the material by observing the flame spread along the specimen."

Sometimes called the "tunnel test," the ASTM E84 test is performed with a tunnel-shaped test apparatus measuring 20 inches by 25 feet. After foam is installed in the tunnel, the material is exposed to a 4-foot-long flame at one end of the tunnel for 10 minutes. The material is then rated for smoke development and flame spread.

The tunnel used in the ASTM E84 tests has physical limitations. "The E84 tunnel has a lid that drops down, and a water bath around the tunnel to create an airtight seal," explains James Andersen from BASF. "The maximum thickness you can test is typically 4 inches. In some cases they can use aluminum foil around the edge of the lid and test a sample above 4 inches, especially if it is a sample of even thickness. But that is tough to do with spray foam, because of its unevenness. So, for the E84 test, we typically say that 4 inches is as good as it goes."

If It's Tested at 4 Inches, You Can't Install It Thicker

Mason Knowles, a consultant and spray-foam expert from Reston, Virginia, confirms Andersen's account. "To get your E84 test on foam plastic, it has to be tested at the thickness intended for use," Knowles told ***EDU***. "The great majority of test facilities can only test up to 4 inches, although some can test up to 5 inches."

Foams tested at a 4-inch thickness cannot be installed at a thickness exceeding 4 inches — unless a manufacturer tests the foam using alternate test methods acceptable to ICC-ES. "All foam plastics have to meet the ASTM E84 test to be used," explains Roger Morrison, a production manager at North Carolina Foam Industries in Mount Airy, North Carolina. "Due to equipment limitations, the maximum thickness you can test with that apparatus is 4 inches. To go any thicker than that you have to do full-scale testing — for example, a small room corner test. The ICC Evaluation Service will recognize your tested value up to the limit of E84 test, and they will recognize greater thicknesses with full-scale testing." There are several full-scale test methods to choose from, including ASTM E119, "Standard Test Methods for Fire Tests of Building Construction and Materials."

It's Easier For Thin Foam To Pass the Test

Manufacturers establish maximum thickness limitations for their spray foam products for two reasons: it's harder for thick (e.g., 4-inch) layers of foam to pass the ASTM E84 test than thinner (e.g., 2-inch) layers; and full-scale testing of wall and ceiling assemblies is so expensive that many manufacturers choose not to pay for them. "Some manufacturers have gone in and performed the E84 test at less than 4 inches, because the thinner the foam, the easier it is to pass the smoke and flame spread tests," says Andersen. "It's tougher to meet the flame-spread and smoke requirements at a thicker application."

Andersen's explanation implies that the smoke and flame-spread characteristics of thicker foam may be more dangerous than those of thinner foam. In any case, many foam manufacturers can't afford to test their foam for applications thicker than 4 inches. "If you do a full-scale test, you can test a wall or ceiling with thicker foam," says Andersen. "But those tests are more expensive."

One spray foam manufacturer that has invested in full-scale testing is BASF (see Figure 3). "The E84 test evaluates the flame spread characteristics of the material," says Andersen. "In a full-scale enclosed room test, where you start putting the foam into walls, roofs, or ceilings, you are testing a construction. Let's say it's 8 feet by 10 feet by 10 feet. It's a room, with a floor, ceiling, and walls. You install spray foam in the wall, and then you have sheetrock. There's a ceiling, and you spray foam down from above onto the ceiling sheetrock. We did this test with 8 inches of foam in the walls and 11 inches in the ceiling."

Since the full-scale room test described by Andersen includes a layer of gypsum wallboard, passing flame-spread and smoke requirements is relatively easy. It should be emphasized, however, that full-scale room tests are only applicable to installations of foam using the same building materials as those used in the test. If the full-scale testing was performed on wall and ceiling assemblies covered with gypsum drywall — as was the case for the BASF testing described by Andersen — then the results cannot be used to obtain approval for the installation of spray foam without drywall protection.

Maximum Installation Thickness Per Pass

In addition to establishing maximum thickness restrictions for cured foam, manufacturers have also established maximum thickness restrictions for each pass of sprayed foam during installation. Depending on the product, installers are warned to restrict spray foam installations to a maximum thickness of 1 ½ to 5 inches per pass (see "Maximum Thickness Restrictions During Spray Foam Installation"). In general, ½-pound-density foams can be installed in a thicker layer than 2-pound-density foams.

Like concrete curing, the curing of two-component spray polyurethane foam is an exothermic (heat-generating) chemical reaction. A thinner installation of spray foam will dissipate heat more quickly than a thicker installation.

Spontaneous Combustion

One distributor of SPF products, Pro-Tech Spray Polyurethane Foam of Scottsdale, Arizona, warns installers of its Spray System P-2.8 (a roofing foam) that installations thicker than 4 inches can catch fire: "If this thickness is exceeded, the temperature buildup within the foam may cause internal charring of the foam applied, seriously affecting the quality and physical properties of the foam. Under certain conditions, applications exceeding this maximum recommended thickness may cause spontaneous combustion of the foam to occur, often hours after the foam was applied."

Mason Knowles agrees that ignoring thickness limitations when installing spray foam can be dangerous. "After a certain thickness, the physical properties of the foam can be affected by the heat of the exothermic reaction," said Knowles. "The foam can start to char or, in extreme cases, even catch on fire. The amount of heat can vary depending on the formula. How much heat is built up by the reaction depends partly on the speed of the reaction." According to Knowles, it is usually safe to install a second layer of foam after allowing the first layer to cure for about 15 minutes. "I have never seen a foam that you couldn't spray in a 2-inch pass and then come back in 10 or 15 minutes and spray another 2 inches on top," Knowles told ***EDU***.

Maximum Thickness Restrictions During Spray Foam Installation

Because two-component spray foam cures by means of an exothermic reaction, spray-foam installers must exercise care to avoid dangerous heat build-up in freshly sprayed foam. To avoid problems, most spray foam manufacturers advise installers to install SPF in thin layers.

Volatile Free is a distributor of spray polyurethane foam products in Brookfield, Wisconsin. The specification sheet for one Volatile Free product, VFI-714, advises, "VFI-714 is a class I, closed-cell 1.91 lb., two-component, liquid spray applied, HFC blown, rigid polyurethane foam. Apply at a minimum thickness of one inch to a maximum thickness five inches per pass."

Pro-Tech Spray Polyurethane Foam (Scottsdale, Arizona) provides the following advice to installers of its roofing foam, Spray System P-2.8: "Urethane foam must not be applied to thickness exceeding 4 inches in 24 hours."

Polythane Systems is a distributor of spray polyurethane foam products that advises, "The maximum thickness you can spray foam is 1 ½" thick. Any thicker than 1 ½", thermal degradation starts to affect the properties of the foam. When spraying foam at the recommended thickness, care should be taken so that time is allowed between passes for the heat dissipate."

Hesterman Technical Services of Regina, Saskatchewan advises installers of its HTS 3100 series 2-pound-density foam, "Maximum pass thickness is 1.5 inches thick."

Roger Morrison emphasizes that different types of foam have different limitations. "The maximum application thickness for spray foam varies," said Morrison. "It depends on how the foam is catalyzed. If it is heavily catalyzed, you will be restricted to a thinner application, since heat from the exothermic reaction is generated rapidly. It will vary from formulation to formulation. Our 2-pound foam can be installed at a thickness of up to 2 inches. We've even performed tests with applications up to 12 inches thick. That's not ideal, certainly — there are some problems there — but it didn't burst into flames."

Andersen of BASF points out that foam installed in thin layers is of a higher quality than foam installed too thickly. "If you install polyurethane foam at a greater thickness, you end up decreasing the foam density," said Andersen. "Normally, what we teach is that all foam applications should be installed in ¾-inch to 3-inch-thick lifts. If foam is applied thick and quick — say, 4 inches thick — you gain yield. You can cover more wall with less foam. But the foam will be less dense. It will also build up heat from the exothermic reaction, and you can get problems."

Rewriting Confusing Documents

Since spray-foam contractors are trained to avoid dangerous heat buildup during spraying operations, most builders don't need to worry about maximum thickness limitations for each pass of sprayed foam. Instead, builders should focus on assembling documents showing that the thickness of cured foam specified for their project does not exceed the recommendations of the SPF manufacturer.

Since manufacturers' specifications and ESRs are far from clear, some building officials have been lobbying spray foam manufacturers and the ICC-ES to clarify maximum thickness limitations. Due in part to suggestions from Seattle building official John Hogan, the "Acceptance Criteria for Foam Plastic Insulation" (AC 12) document has already been rewritten. Revisions to AC 12 approved in February 2007 require (in section 2.2.1), "For spray-applied materials, installation instructions shall specify the maximum thickness that can be sprayed with each pass and the maximum number of passes allowed. If more than one spraying is allowed, the report shall include any restrictions, including, but not limited to, curing time and preparation."

Not all manufacturers of SPF products are moving in the direction of greater clarity, however. In fact, some manufacturers seem content to enjoy the benefits of the many ambiguities in SPF documents. Interviews with builders reveal that many contractors routinely install spray foam at greater thicknesses than allowed in manufacturers' specifications; whether these installations are safe or potentially hazardous is far from clear.

Advice To Prudent Builders

Since many local building inspectors are completely unaware of maximum thickness limitations for spray polyurethane foam, some builders have gained easy approval for 6-inch or 7-inch installations of spray foam. Unless the builder has assembled several key documents, however, such installations open the builder to considerable liability, especially in the event of a fire. A prudent builder should know:

- The ASTM E84 tests for most spray polyurethane foams limit the maximum installed thickness of foams to 4 inches or less. The ASTM E84 tests for some SPF products limit installations to a maximum of only 2 inches. Builders contemplating the use of spray foam should ask their spray foam contractor to provide a copy of the ASTM E84 test for the specific type of foam under consideration.

- Large-scale room tests have been performed for some, but not all, SPF products. These tests may allow more than 4 inches of spray foam to be installed, as long as the thickness of the foam does not exceed the thickness used in the test, and as long as the builder installs the same ignition barrier or thermal barrier (for example, gypsum drywall) that the SPF manufacturer used in the large-scale room test. Builders contemplating the use of more than 4 inches of spray foam should ask the SPF manufacturer for a copy of the laboratory report documenting the full-scale test allowing for thicker foam installations.

- The spray-foam industry is currently responding to criticism of controversial crawlspace tests sometimes used to gain approval for spray polyurethane foams installed in attics without a thermal barrier like gypsum drywall (see ***EDU***, November 2007). Most observers predict that the industry will move away from the lax testing procedures currently in use that compare the performance of spray foam with that of exposed kraft paper. Builders installing spray foam in attics without any ignition barrier, as well as builders using intumescent coatings as ignition barriers, should be aware that many experts doubt that such attic installations meet code requirements.