Calculating Yield in Sprayfoam Applications,

A common question among sprayfoam contractors is "how much yield can I get from my sprayfoam." Obtaining good yield from your sprayfoam can lead to a better bottom line. In many cases, a sprayfoam contractor will base their purchasing decision on the yield they expect to obtain from a nominal low density, medium density or high density sprayfoam.

But there are many factors that affect a product's yield. For example a nominal 2 lb density foam can yield anywhere from 3000 board foot coverage to over 5000 board foot coverage depending on the job.

Consequently, this tends to affect the contractor if they fail to account for the factors that influence the yield of their foam. To complicate the issue, suppliers may offer a contractor a wide variation of yield claims by their sales staff. Some companies tend to exaggerate slightly the yield expected by emphasizing perfect conditions, while other suppliers are prone to more conservative estimates emphasizing factors that typically can reduce the products yield.

So, with the competing tendencies, how can a contractor determine what yield to expect from a supplier's foam?

The answer is relatively simple, but fairly complex at the same time.

<u>Start with Density:</u>

Sprayfoam is categorized by its density. The density of a sprayfoam is what the reacted material weighs per cubic foot. Each supplier lists the core density of the product on their data sheet. In order to determine a material's density, the manufacture takes a small liquid sample of the A side and the B side and mixes it at room temperature with a high speed mixer. The foam's reaction time is recorded and the resulting foam is cut and the center weighed to obtain its density. Each batch of sprayfoam is tested in this way by the manufacturer and before it can be placed in drums or totes, the foam must weigh within the supplier's quality control parameters. For example, a sprayfoam that has a listed core density of 2.0 pounds per cubic foot (pcf) would typically be allowed to have a tested core density between 1.9 to 2.1 pcf.

Generically, an open cell, low density foam would range between 0.4 to .06 pcf. Closed cell foams used for interior insulation (also called medium density foam) ranges from 1.5 to 2 lb pcf. And roofing foams typically average between 2.5 -3.5 lb pcf.

As demonstrated in the table below, the theoretical yield of the product can be obtained from the density of the material by just calculating how many board feet (a board foot is 1 sq ft of material at 1 inch thick) could be covered by a cubic foot of the foam. Each cubic foot of foam in theory will yield 12 board feet. Therefore, a foam with the density

of 2 pounds per cubic foot should yield 12 board feet per 2 pounds or 6 board feet per for every pound.

Table 1: Theoretical Yield based on Density & Foam Type

Type of Foam	Core Density (avg pcf)	Theoretical Yield
Open Cell	0.5	24 board ft per pound
Closed Cell Insulation Foam (interior)	2.0	6 board ft per pound
Closed Cell Roofing Foam	3.0	4 board ft per pound

Using the theoretical yield value is inappropriate. Consider that the density listed on a technical data sheet is calculated typically based on a core foam sample that was a result of a free rise of foam in a cup. It is virtually impossible to obtain the same yield in the field. When foam is sprayed at high pressure to a substrate the resulting foam will naturally be a slightly higher density than if it was the result of a free rise. This by itself reduces the yield of the product. In addition, a slightly higher density skin forms on the substrate/foam interface and on the top surface of the reacted foam. This also reduces yield. So in the best of environments a nominal 2 pcf sprayfoam typically creates a sprayed in place density of approximately 2.2 pcf.

(note: Some manufacturers calculate their yield based on a sprayed-in-place sample. So, in those cases, the density listed on the data sheet would be closer to actual yield. However, the density of the material is still taken at the core, so it would still have a lower density that in an actual application.)

A considerable variety of factors can further reduce the yield expected in the field including:

- Substrate temperature
- Substrate profile
- Compartment vs. Open spray
- Variation of thickness
- Uniformity of application/spray technique
- Thickness of application
- Number of lifts
- Quality of mix and proportion of material

Substrate Temperature: The colder the surface the less the foam will rise and the poorer the yield. This will vary from foam to foam. However, it can reasonably be assumed that for every 10 degrees below 70 degrees to 50 degrees F, you can expect a 10-15% reduction in yield. Below 50 degrees the decline in yield can be even more significant.

Substrate Profile: Substrates vary in profile from very smooth to very rough. Rougher surface such as aggregate covered BUR require an additional 15% of foam at a 2 inch thickness. Corrugated metal surfaces require from 20-25% greater material for the same

thickness as a smooth surface. Standing seam metal decks may require up to 30% more material.

Compartment vs. Open Spray: Compartment spraying consists of installing foam within a cavity space such as between wood or metal studs in wall or ceiling applications. Extra foam is required to fully attach the foam to the studs and the foam is less uniform. Expect to lose 10% coverage in this situation over an open wall or ceiling area.

Uniformity of Application: Suppliers typically recommend yields based on an ideal spray technique where the foam is applied to a fairly uniform thickness. In closed cell foam applications, a good applicator can install to a minimum thickness tolerance of 1/2 inch at a 3 inch application. In open cell foam, a good applicator can spray to within a ¾ to 1 inch tolerance at 5.5 inches.

But if the applicator is not able to maintain that uniformity, add 15% to the amount of foam needed to match the minimum thickness specific for every 1/2 inch extra foam sprayed to a 3 inch thickness and 10% to foam sprayed to a 5 inch thickness.

Thickness of Lifts: The thicker the lift of a closed cell foam, the greater the yield. This is a double edge sword. Thicker lifts have fewer skins, making the foam less dense and increasing the yield. But, thicker lifts also can affect the physical properties of the foam. Each foam has its "sweet spot" where you obtain the maximum yield with the desired physical properties. For most closed cell foams, this would range between 1.5 to 2 inches. Any thicker and the exothermic heat of the foam can affect the cell structure causing the foam to be weaker and less dimensionally stable. Most suppliers report a maximum thickness the foam can be installed without having negative effects (2 inches is typical). But, the thickness toleration can vary depending on the climate, type of spraygun configuration, temperature of the substrate & foam and other factors. To be safe, a contractor can measure the temperature of the foam as it is setting up. After 3-5 minutes, the interior temperature of the foam should not exceed 220 degrees F.

Number of Lifts: The greater the number of lifts, the greater the number of high density skins created within the foam. The high density skins reduce the yield slightly. An average foam yield reduction per lift would average between 2-3%

Trimming: The amount of foam that has to be trimmed will affect your yield. When spraying open cell foam between stud wall cavities, the applicator overfills the cavity. A good applicator may need to trim up to 20% of the open cell foam from a 2 x 4 stud wall and around 15% from a 2 x 6 wall. Closed cell foam may or may not need trimming. If filling a 2 x 4 stud wall expect a good applicator to trim approximately 5% of the closed cell foam and up to 3% on a 2 x 6 stud wall.

Quality of Mix or Proportion: If the foam is not mixed correctly or is slightly off ratio, the yield can also be affected. There is no good rule of thumb, but if your yield is consistently off and the other factors have been ruled out, then check out the foam's

density and compressive strength. If the properties are significantly higher or lower than as indicated on the data sheet, the foam often has a mix or ratio problem.

Table 2: Theoretical Yield vs. Actual

Condition	Reduction in Yield
Theoretical	0
Sprayed in Place (perfect conditions)	10-15%
Rough Profile corrugated metal aggregate BUR	 20-25% 15%
Cold Substrate 60 degree F 50 degree F	 10-15% 20-30%
Compartment Spray (between studs)	10%
Uniformity (@ 3inches 1/2 inch variance 3/4 inch variance 1 inch variance	 15% 22.5% 30%
Number of Lifts 2 3	 2-3% 4-6%
Trimming Open Cell 2 x 4 fill 2 x 6 fill	 20% 15%
Trimming Closed Cell 2 x 4 fill 2 x 6 fill	 5% 3%
Poor Mix or Off Ratio	Varies

Taking these factors into consideration, a good applicator spraying in moderate temperatures (70 – 80 degrees F) would have average yields as follows.

Open Cell Foam 2 x 4 stud wall	12,000 - 15,000 – bd ft per 1,000 lbs
Open Cell Foam Attic (no trimming)	15,000 – 17,000 bd ft per 1,000 lbs
2 lb Closed Cell Foam 2 x 4 stud wall	4,000 – 4200 bd ft per 1,000 lbs
2 lb Closed Cell Foam Open wall application	4,250 – 4,500 bd ft per 1,000 lbs
3 lb Closed Cell Foam	

BUR w/ aggregate	2,250 – 2,500 bd ft per 1000 lbs
Smooth Mod bit	2,600 – 3,000 bd ft per 1000 lbs

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Checking Foam Yield

In order to determine the yield of your foam, it is necessary to obtain accurate information on the average thickness of the foam, the area sprayed and the total volume of foam sprayed. Once this information is obtained the yield can be obtained by dividing the board ft per lb by the total area sprayed.

Example: Determine the yield based on the following information

Area:	1000 sq ft
Avg thickness	3.5 inches
Strokes on proportioner (Graco E-30)	1500

Step 1: Average thickness can be obtained by measuring 15 spots including both high and low areas. Total avg thickness = 3.5 inches

Step 2: Determine how many board foot of foam was sprayed by using the following formula:

Area x Avg thickness = total board feet of foam
1000 sq ft x 3.5 inches = 3500 board feet

Step 3: Calculate total amount of foam used: According to the spec sheet, a Graco E-30 proportioner with a size 100 cylinder requires 1838 strokes to empty 1000 lbs of material. So the formula to determine the foam used is:

Strokes counted divided by strokes per 1000 lbs

1500 divided by 1838 = 816 lbs of material

(Alternatively a contractor can weigh the drums before and after to determine the amount of foam used.)

Step 4: Determine yield: To determine the yield just divide the amount of material sprayed into the total board foot.

3500 board feet divided by 816 pound of foam = 4.28 board feet per pound of foam.

This coverage would be consistent with spraying a nominal 2 lb density foam in stud wall cavities under normal conditions.

Checking your foam for defects:

There will be some variation of yield based on how well the applicator sprays and the temperature of the substrate. But, if you get much better yield than is expected, taking into consideration all of the factors listed above, then you should check out your foam.

The physical properties of the foam should be in line with the manufacturer's data sheet. Two things you can check in the field are density and compressive strength. You need the right equipment for both.

For density, use a scale that can measure grams or fractions of ounces. For compressive strength compressor strength testers such as a Com-Ten can be used.

Make sure the sample can be measured accurately to find the cubic volume and the weight.

Physical properties of sprayfoam samples taken from field samples typically range as follows:

Foam Type (based on core density)	Typical Sprayed-in-Place Density (pcf)	Compressive Strength
Open Cell 0.4-0.6 pcf	0.5 – 0.75	2-5 psi
1.5 lb Closed Cell	1.7 – 2.0	15 – 20 psi
2 lb Closed Cell	2.2 – 2.5	20 – 28 psi
3 lb Closed Cell	3.2 – 3.6	40 – 60 psi

An accurate understanding of your actual foam yield is essential to your bottom line. Be wary of overstated claims by suppliers. Train your crews to provide accurate foam yield data and to reduce waste. Make sure that you are taking all of the factors into consideration before turning in that proposal. It will save you money and maximize profitability of the project.

Yield Article Photos

Photo 1: Uniform application of closed cell foam within ½” tolerance

Open cell foam application: Allow at least 20 % waste factor for trimming when Filling stud walls

Closed cell foam with slightly irregular surface and varying thickness. Add 5-10% extra foam

Compare the foam sprayed on the right to the foam on the left. The foam on the right would require 30 – 40% more foam to bring the thickness to the specified level.

This roofing application required more than 50% extra foam to build up to its specified 2 inches

The same crew after spray technique training were able to apply much more uniform applications of foam. Note: corrugated metal surfaces require at least 20% more foam when spraying 2 inch minimum thickness

An almost perfect application of sprayfoam roofing

This rough application of 2 lb foam to a ceiling resulted in
a waste of 50% of the material

This would represent a very uniform application of open cell foam
With thickness variation of 1 inch or less at 6.5 inches

The specification called for 3.5 inches of closed cell foam. This foam measured between 2 – 10 inches thick. Much of this was sprayed to a cold substrate which reduced the foam yield even more.
What huge waste of foam!