Understanding Yield with a Spray Foam System

Theoretical Yield

Theoretical yield is the maximum amount of foam in cubic feet (ft^3) a set of material will produce under perfect conditions assuming no losses. Several things can impact yield so achieving the theoretical yield is impossible. In spray foam, yield is measured by board feet where 1 ft^3= 12 bf at 1 inch thickness.

Theoretical Yield (bf) = Set Weight (lb.) x 12 / System Density (lb./ ft^3)

For example, a 1,000lb set of chemical with a core density of 0.5 lb./ ft^3
Theoretical Yield = 22,560 bf = (940 lb. x 12) / 0.5 lb./ ft^3

Actual Yield

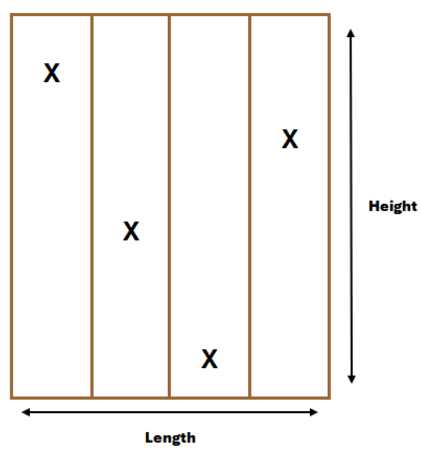
Actual yield is the amount of foam in cubic feet (ft^3) a set of material produced in real-world conditions. Actual yield is always lower than theoretical yield due to various factors affecting the application process. Download NCFI's Yield Calculator as an easy tool to determine your efficiency. NCFI Yield Calculator Template.xlsx

Designate a symmetrical area to spray at least 10 x 8 feet and record the dimensions in inches.

1. Clear the cycle count on the machine.
2. Spray the designated area to the specified thickness.
3. Record the stroke count after the spray.
4. Take multiple depth checks per cavity and calculate average thickness in inches.

Calculating Board Footage

Board Footage Calculation	
Length (In)	96
# of Vertical Studs	5
Height (In)	120
# of Horizontal Studs	2
Average Thickness (In)	4
Board Feet	287.63



To calculate the board footage correctly, you must consider and subtract the studs from the equation. It is assumed that the stud is 1.5 inches thick.

Wall Area = (Length -(# Vertical Studs * 1.5)) * (Height -(Horizontal Studs * 1.5))
Wall Square Footage = Wall Area * Average Thickness
Board Foot = Wall Square Footage / 144

Example: Wall Area = (96 – (5 * 1.5)) * (120 –(2 * 1.5) = 10,354.5
Wall Square Footage = 10,354.5 * 4 = 41,418
Board Foot = 41,418 /144 = 287.625

Calculating Yield

Yield/Efficiency		
Total Board Feet	287.63	
Proportioner	E-30	
Machine Output (gal/stroke)	0.0272	
Product	12-008	
Resin Density (lbs/gal)	9.120	
Stroke Count	65	
Total Gallons	1.768	= Machine Output * Stroke Count
Total lbs.	16.124	= Resin Density / Total Gallons
Board Feet/lb.	17.838	= Total Board Feet / Total Pounds
Yield	16767.85	= (Board Feet/lb.) * Set Weight
Efficiency	74.33%	= Actual Yield/ Theoretical Yield

Proportioners	Gallon/cycle
E-20	0.0104
E-30	0.0272
E-XP1	0.0104
E-XP2	0.0203
H-25	0.063
H-30	0.073
H-40	0.063
H-50	0.073
FF 1600	0.0313
H20/35 Pro	0.063
Class C MH	0.042
PH-2	0.037
PH-25	0.063
PH-40	0.063
PH-55	0.063

Products	Set Weight	Density	Density	Gal /Drum	System Density	Theoretical
12-008	940	1.09	9.12	48.24	0.50	22,560
11-036	980	1.20	10.01	47.97	2.00	5,880
11-033	980	1.20	9.99	48.05	1.70	6,918
11-037	980	1.20	10.02	47.93	2.00	5,880
11-035	980	1.18	9.84	48.78	2.00	5,880
10-016 2.8	1000	1.24	10.31	48.47	2.80	4,286
10-016 3.0	1000	1.24	10.31	48.47	3.00	4,000

To calculate the actual yield, you will need to know a few factors. First you need board foot calculated in the previous step. Next you need to know the output of your machine, how many gallons per stroke your machine delivers. Lastly you will need to know the resin density which can be found on the manufacturer's TDS. As an example, we will use NCFI's B-12-008 on a Graco E-30.

First calculate the total pounds applied in your designated area:

Total Pounds = Resin Density / (Machine Output * Stroke Count)

Example: Total Pounds = (9.12 / (0.0272 * 65) = 16.124

Next, calculate the actual yield:

Actual Yield = (Board Foot / Total Pounds) * Set Weight

Example: Actual Yield = (287.625 / 16.124) * 940 = 16, 767.85

Calculating Efficiency

Efficiency refers to how effectively the applicator applies the foam and plays a critical role in estimating how much usable foam you can expect from a sprayer and a set of chemicals. Since it's impossible to be 100% efficient based on a number of factors, it is common to see a 65-75% efficiency on open cell systems and 70-80% efficiency on closed cell systems. If you monitor your efficiency with every job and notice a large drop off, it's a good indication that something has changed or is wrong.

Efficiency % = Actual Yield / Theoretical Yield * 100

Example: Efficiency = 16,768 / 22,560 = 74%

Factors Affecting Actual Yield

Several factors affect spray foam yield, each influencing how much usable foam you get per set. Yield is affected by everything from materials to environmental conditions to applicator technique.

Material Properties

Material Temperature - If the drum temperatures are too low, the viscosity of the chemical will thicken and may cause pumps to cavitate. As cold material is transferred into the proportioner and heated up, the volume changes inside the machine which results in an off-ratio mix being supplied to the gun causing off-ratio foam. It is recommended to slowly bring up the temperature of your material to 65-85°F in a warm room 24-48 hours before application.

Age & Condition of Material – The age of spray foam materials can significantly affect yield due to chemical degradation, separation, or contamination over time. Even if the material looks okay, the performance can drop sharply past their expiration date. Hot storage conditions accelerate degradation causing poor rise and bad cell structure. Freezing storage conditions can cause the isocyanate to crystalize or dimerize which can lead to blockages and off ratio foam. Long-term or expired material may be separated and cause the spray to be unstable or inconsistent.

Substrate Conditions

Surface Contamination -Clean, dry, and well-prepared substrate is essential for proper adhesion and expansion. Wet or dirty substrates may reduce adhesion and increase scrap.

Substrate Type- Higher conductivity materials such as concrete or metal will suck the heat out of the reaction and decrease the foam's expansion. Spray a ½ inch flash pass to heat up the material then apply your maximum thickness on the second pass. The profile of a substrate can also impact yield. Corrugated materials can consume 20-25% more material compared to flat smooth materials and should be estimated correctly.

Substrate Temperature- Substrate temperatures (above 70°F) is crucial for proper expansion. Colder substrates will reduce the exotherm of the reaction and affect how well the foam blows to its maximum thickness. For every 10°F below 70°F you could see a 10-15% reduction in yield. Substrate temperatures below 50°F will show an even more significant decline in yield. To improve yield, heat the building to a minimum temperature of 50°F or spray a sacrificial ½ inch pass. The sacrificial pass will heat the substrate by utilizing a minimal amount of material and allows the second pass to get its full exothermic reaction for maximum expansion.

Substrate Moisture- Wet/damp substrates can lead to delamination and foam failure. Ensure substrate moisture is ≤19% to avoid foam that does not rise correctly, blisters, pulls away from the studs, or does not adhere to the substrate.

Applicator Technique

Gun Distance & Angle- Always hold spray gun perpendicular (90-degree angle) to the substrate. Spraying at an angle can cause a lack of adhesion and increase scrap. Hold the gun approximately 18-24" away from the substrate. Spraying further away will reduce the chemical temperature before it reaches the substrate and reduce the foam's expansion.

Overlap & Spray Speed- Apply the foam by spraying into the wet line, the section right before it starts rising, with a 60-80% overlap in passes. Avoid spraying onto rising foam as this can lead to poor quality foam and excessive dripping. Over-spraying or inconsistent application waste material. Any foam that must be trimmed off is waste and impacts your yield. Adjust the spray speed and gun distance to avoid accidental overfilling.

Pass Thickness

Thinner passes do not generate enough exothermic heat to fully expand the foam. The optimal pass thickness for closed cell systems is 1.5-2 inches and 3-5 inches in open cell systems.

Thicker passes may generate too much heat that can collapse the cell structure, scorch the foam, or cause shrinking. Thick base layers can also crust over, preventing proper bonding with subsequent layers leading to delamination. Allow sufficient cool-down times between passes to ensure good cohesion and prevent from charring. Refer to the application guideline specific to the product for guidelines on pass thickness.

Number of Passes- Each pass will produce a skin which is a densified layer of the foam. This skin will increase the overall density and reduce yield by 2-3% with each layer. Apply the foam to the full thickness spraying the maximum thickness allowed for the product.

Environmental Factors

Humidity- High humidity can cause the foam to over-expand and weaken the cell structure which may lead to shrinkage, cracking or spongy texture. Avoid spraying in conditions where the substrate temperature is within 5°F of the dew point.

Wind- Wind directly reduces yield because material is wasted and blown away in the air or does not make it to the intended surface. Wind can also distort the spray pattern making it difficult to maintain uniform thickness which often leads to overapplication wasting material or underapplication which requires recoating. Both reduce efficiency and yield. Avoid spraying in winds > 15 mph or use windbreaks to protect the spray. Light winds (5-10 mph) can result in 5-15% yield loss, while stronger winds (>15 mph) can dramatically increase the loss to >25%.

Altitude- Higher altitudes can affect the yield because of how it influences atmospheric pressure, material expansion and curing behavior. High altitudes (>5,000 ft) allow the foam to expand more because there is less resistance from the lower ambient air pressure. While this might increase the yield, it can also lead to weaker cell walls. Care should be taken to avoid spraying passes that are too thick that allows the foam to over expand too much past its stable density. The foam will also kick off faster because the boiling points of blowing agents will be lower. You may need to adjust your temperature and pressure settings and slow down your spray speed for optimal application.

Equipment Factors

Machine Temperature- Material temperature, whether it's your machine setpoints or your chemical in the drum, will greatly impact your yield. If you set your machine temperatures are too low, your foam will not get the full exothermic reaction to maximize the expansion and your densities will be higher. Ensure that you dial in your settings, starting lower and increasing in 2-3°F increments until you are optimized. Refer to the product's application guideline for tips on dialing in that specific product.

Machine Pressure- Poor atomization or mixing due to incorrect pressure can cause off-ratio foam or voids. Set pressures to a minimum of 1000 psi dynamic pressure to get a good mix and avoid creating scrap. Do not offset pressures more than 300 psi to avoid spraying off-ratio foam. Avoid setting the pressure too high to reduce mist. Mist or overspray is a loss chemical which impacts yield because it never reaches the substrate.

Mixing Chamber Size- Larger mixing chambers increase the flow of material and reduces the ability of the chemical to heat up in the proportion. Smaller mixing chambers will allow the chemical more time to pass over the block heaters. Ensure the mixing chamber size can handle the delta T of the proportioner.

Poor Equipment- Equipment issues often cause foam to be off-ratio, poorly mixed, or improperly sprayed; all of which lead to wasted material and lower yields. Perform regular maintenance on your machine and replace damaged parts as needed to keep your equipment running efficiently.

Poor Ratio Control may be caused by worn/ leaking seals, crystalized hose and clogged filters/ Y-strainers. If one side is restricted, the foam may not rise properly or cure fully. Off-ratio foam is waste and must be removed.

Low or Inconsistent Spray Pressure may be caused by clogged orifices in the spray gun or improper heating. The spray may be poorly atomized and appear chunky or stringy which produces foam with poor cell structure.

Poor Heating may be caused by faulty thermocouples. The foam may spray too cold causing poor expansion or spray too hot causing brittleness and shrinking.

Gun Issues may be caused by dirty or worn mix chambers, improper air purge, mechanical purge failure, or damaged tips. The spray pattern may drift causing uneven coverage or overspray. The mixing may be insufficient, causing bad foam that must be removed.