Johns Manville
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Insulation Intel®

EXPLORING THE EFFICACY OF HIGH LIFT SPRAY FOAM INSULATION

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ABSTRACT

As the construction industry faces growing challenges with labor shortages and compressed deadlines, time has become an increasingly more valuable resource for insulation contractors and builders. In an effort to improve efficiency and save time during installation, many spray foam insulation installers have begun utilizing high lift, closed-cell, spray polyurethane foams (spray foam) that are installed with a thick, single-pass installation method. In this method, the installer sprays one, thick layer of foam (greater than 4 inches) to reach the total thickness required to achieve the desired R-value. While this method has been endorsed by some spray foam manufacturers, little data has been published regarding the integrity of spray foams that have been sprayed in a single, thick layer. In fact, some countries, like Canada, do not allow passes greater than 2 inches because of this lack of testing and data. In the U.S., however, written foam standards do not account for lift recommendations, which allows high lift foam manufacturers to extrapolate performance values for thicker, high lift foams based on testing and data reported at thinner lifts, such as 2 inches.

Given the relative absence of testing and data on the performance and integrity of high lift foams, Johns Manville (JM) recently performed comparative testing between JM Corbond® III Closed-cell and a competitive high lift closed-cell spray foam product (Product A). JM Corbond III is not a high lift spray foam; however, in the U.S., JM Corbond III can be installed in immediate successive passes with no wait time between passes, achieving the same thicknesses as high lift spray foams in approximately the same amount of time. For this test, JM Corbond III was installed per JM's guidelines, spraying multiple layers in immediate passes to achieve the desired thickness. The competitive high lift foam was sprayed, per the manufacturer's guidelines, in a single, thick pass, to achieve the same overall thickness, but in one layer.

This study compared the installation times to determine whether there was a significant time-saving benefit to either installation method (spraying a single, high lift pass or spraying several immediate passes). The physical and performance properties of the foams were then analyzed to determine whether the installation method influenced the material properties of the products. The results of this study demonstrated that there was almost no difference in installation times; however, some of the physical and performance characteristics of the high lift foam, Product A, were compromised when sprayed in a single, thick pass. These data suggest that performance characteristics of spray foam insulation cannot be extrapolated from thinner lifts to thicker lifts, and that materials should be tested at varying lift thicknesses to confirm performance integrity.

Prior to utilizing a high lift foam, spray foam specifiers and installers should query their manufacturer for the actual test data to validate that the high lift foam will retain its physical performance characteristics when installed in a single, thick pass.

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INTRODUCTION

On construction sites, there is ever-increasing pressure to improve efficiencies and meet compressing timelines. This pressure is exacerbated by the growing shortage of skilled labor in the construction industry. These two variables have led to the introduction of several practices and products designed to expedite the overall construction process. One such product has been high lift spray foam. High lift spray foam is designed to be sprayed in thicker layers (lifts) than standard spray foams. This purportedly allows the installer to achieve the necessary insulation thickness and R-value in fewer layers, subsequently saving time during installation due to the removal of the 30-minute wait time that is typically required between layers of high lift foams to reduce fire risk. Ultimately, the objective of this installation method is to allow spray foam insulation contractors to complete jobs more quickly.

While this method has been endorsed by some spray foam manufacturers, little information has been published regarding the integrity of spray foams that have been sprayed in a single, thick layer. In the U.S., written foam standards do not account for lift recommendations, which allows high lift foam manufacturers to extrapolate performance values for thicker, high lift foams based on testing and data reported at thinner lifts, such as 2 inches.

Since written foam standards in the U.S. do not account for lift recommendations, it has not prevented spray foam manufacturers from using their test data on a 2-inch lift to extrapolate the performance values and physical characteristics of thicker lifts, without actually testing the product at those thicknesses.

Given the relative absence of information on this topic, Johns Manville (JM) recently performed comparative testing between JM Corbond® III spray foam and a competitive high lift spray foam product (Product A). JM Corbond III is not a high lift spray foam; however, the JM Corbond III formulation used in the U.S. can be safely applied in a single lift of up to 4 inches or in immediate successive passes to achieve a thickness of up to 7 inches (four, 1.75-inch lifts applied with no wait time between passes).

In the first portion of the testing, a time-study was performed to determine whether there was a time-saving advantage to installing a single pass of Product A high lift foam or immediate successive passes of JM Corbond III. Both materials were installed to the same thickness following the manufacturers' recommended installation guidelines.

The second portion of the testing evaluated the physical and performance characteristics of the foams after being installed per the manufacturers' guidelines. Since the hallmark of a high lift spray foam is that it can be sprayed in thicknesses greater than 4 inches in a single pass, each of the Product A high lift spray foam samples was sprayed to the 5 inches, the manufacturer's recommended maximum lift thickness.

In contrast, the JM Corbond III spray foam samples were sprayed per JM's recommended guidelines (outlined in Table 1) of multiple, thinner lifts sprayed in immediate, successive passes to achieve the appropriate thicknesses for the test. All samples of JM Corbond III and Product A were tested at the same thicknesses for comparative testing.

Table 1: JM Corbond® III Recommended Immediate Pass Thicknesses

Passes	Pass Thickness	Total Thickness
1	4"	4" (R28)
2	2.5" + 2.5"	5" (R35)
3	2" + 2" + 2"	6" (R42)
4	1.75" + 1.75" + 1.75" + 1.75"	7" (R49)

Afterward, the insulations were examined to determine whether their physical and performance characteristics were consistent with manufacturer advertised values for those thicknesses. Spray foam standards, such as AC377, evaluate the quality of spray foam by measuring properties like thermal insulation performance, structural stability, and fire resistance. Among the properties that are evaluated, density, dimensional stability, closed-cell content, and long-term adhesion to the substrate and framing members are the most crucial to the integrity of spray foams. For the purpose of this research, those are the material properties that were evaluated.

APPLICATION EVALUATION

EXOTHERM EVALUATION

Not all spray foams can be installed in immediate successive passes, like JM Corbond III. All spray polyurethane foams are created by an exothermic reaction of two chemicals, the A-side and the B-side. In some spray foams, this reaction can result in temperatures exceeding 350°F in the core of the sample. As the sample gets thicker, the core temperature increases, and vice-versa. If the core temperature exceeds the self-ignition temperature of the foam product or the wood substrate around it (which has an ignition temperature of 482°F), these high temperatures can lead to charring in the center of the foam or even cause a fire. A commonly cited industry maximum is 360°F, which reduces charring and fire risk while also protecting any substrates and framing from damage. Less conservative estimates of up to 392°F have also been recommended, but 360°F was used in this study for the maximum factor of safety.

Fire risk for closed-cell foam due to the exothermic reaction has traditionally led manufacturers to require a 30-minute waiting period between passes to allow the foam to cool. A 7-inch sample of JM Corbond III sprayed in four, immediate passes was evaluated over a 5-hour period to track the temperature curve during cure. The maximum temperature observed in this 7-inch sample of JM Corbond III was 340°F, which is more than 300°F lower than its self-ignition temperature of 649°F and almost 150°F lower than the ignition temperature of wood. The center of the foam sample was not charred or deformed, indicating that the 30-minute wait period can be eliminated when using JM Corbond III without increasing fire risk.

For this reason, JM Corbond III can be used in a comparative study with high lift foams to explore whether the high lift or immediate pass installation method is more efficient and which method contributes to optimal physical and thermal properties.

SPRAY APPLICATION TIME STUDY

In the spray application time study, 7 inches of spray foam was sprayed into four, 14-inch wide wall cavities to evaluate the amount of time required for each installation method. Two of the cavities were sprayed with a single, 7-inch pass of Product A. In the remaining two wall cavities, JM Corbond III was sprayed in four, immediate 1.75-inch passes to a total thickness of 7 inches.

Figure 1 shows a representative side-by-side comparison. The two leftmost wall cavities were sprayed in a single pass with Product A, and the two rightmost cavities were sprayed in four immediate, successive passes with JM Corbond III. A stopwatch was used to measure the time taken to spray a single 14-inch wide wall cavity from bottom to the top of the removable cardboard inserts.

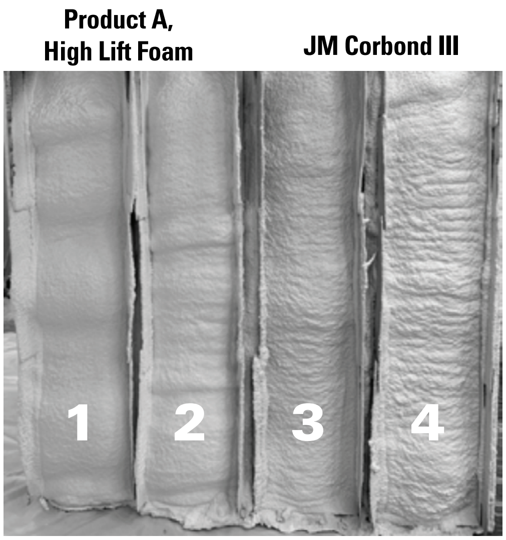


***Figure 1**: Product A sprayed in a single-pass, 7-inch lift (1, 2) and JM Corbond III sprayed in four passes to 7-inch thickness (3, 4).*

On average, the time difference between the two product applications was negligible, with JM Corbond III installing approximately 2 seconds faster than Product A. During a jobsite installation, a time difference this small would likely be insignificant and potentially variable between each cavity. However, it is worth noting that the single-pass samples of Product A have inconsistent thicknesses throughout the cavity, resulting in a lumpy surface.

In a real-world application, the required R-value would not be met on the thinner sections of Product A, and the installer would have to return to the wall cavity to do one or more “touch ups.” This would require additional installation time. By comparison, the four-pass samples of JM Corbond III have a consistent thickness throughout the length of the sample and touch-ups would not be necessary.

In considering installation efficiencies, it is important to keep in mind that spraying a consistent 7-inch pass is much more difficult than spraying four, immediate 1.75-inch passes. During spray foam application, an installer must continually evaluate the rate of lateral and longitudinal motion of the spray gun to achieve the required foam thickness. Furthermore, they must be able to precisely repeat this motion through the length of the spray area. A single-lift application leaves more room for error as the applicator does not have the ability to pause and reset between passes. As a result, high lift foams typically require a more experienced applicator to install the insulation correctly the first time. While the time study demonstrated that the time taken to spray four, 1.75-inch, immediate passes is negligibly less than spraying one 7-inch pass, the immediate passes may, in practice, require noticeably less time if additional time for touch-ups are needed on the high lift foam product to ensure accuracy and consistency.

PHYSICAL PROPERTY COMPARISON

CORE DENSITY

The results of the physical property evaluation determined that the physical integrity was adversely impacted by spraying thick passes of the high lift foam, Product A. The high lift foam exhibited poor dimensional stability, which manifests in the field as “cracking off” of framing members. This can cause warping of the foam within the framing member, or, if the adhesion of the foam to the framing member is strong, it can warp the framing member itself. This not only negatively impacts thermal performance, but the air barrier and vapor retarding properties of closed-cell foams are negated when there is not continuous, integral contact between the foam, the substrate, and all framing members.

By comparison, JM Corbond III, sprayed to the same thickness in two, three, or four immediate passes (in pass thicknesses shown in Table 1, Pg 5) exhibited consistent physical and thermal properties. The intact physical characteristics can easily be seen in Figure 2 below.

JM Corbond III **Product A, High Lift Foam**

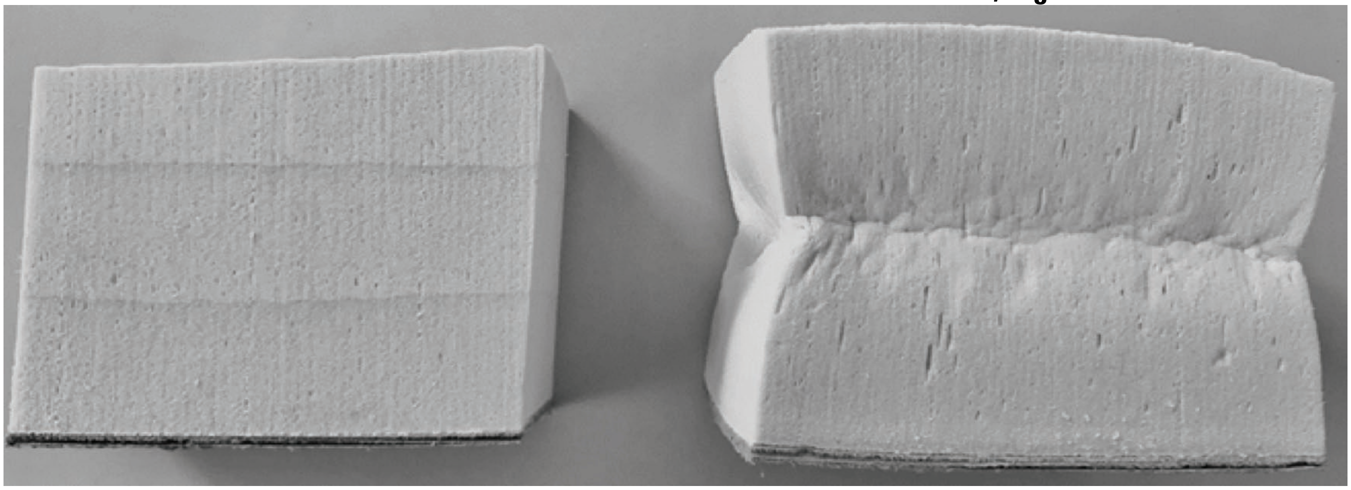


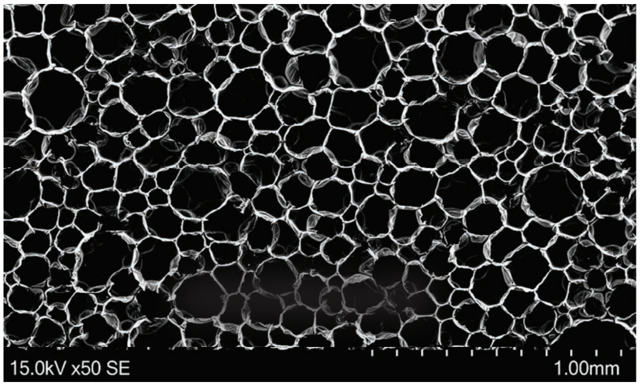
Figure 2*: JM Corbond III closed-cell spray foam sprayed to 6 inches thickness in three, immediate passes (left). Product A, closed-cell, high lift spray foam sprayed to 6 inches in one pass (right).*

Figure 2 demonstrates the difference between JM Corbond III spray foam installed in multiple, immediate passes (left) and Product A high lift spray foam installed in one, high lift pass (right). The “buckling” across the middle of the high lift sample on the right is indicative of a reduction in density throughout the core section of the foam. This density reduction can be common among high lift foams that are installed in a single, thick pass.

While JM Corbond III maintains a consistent density profile when sprayed in immediate passes up to 7 inches (per Table 1), the density profile of the high lift foam varied substantially depending on the thickness of the lift. In the Product A high lift foam samples, the density was relatively consistent in lower, 2-inch lifts, but it became much more variable as the lift thickness increased.

The buckling seen throughout the middle of the Product A high lift sample in Figure 2 results in damaged cells in the core of the sample. When investigating the cellular structure of the sample at a microscopic level, the buckling appears as lacerations penetrating through the deformed (elliptical) cellular structure (Figure 3, right). These lacerations can hinder the structural integrity of the foam and decrease its overall density and closed-cell content. In contrast, the microscopic view of the JM Corbond III sample (Figure 3, left) has a uniform, spherical cellular structure which contributes to its consistent performance and physical characteristics.

JM Corbond III



Product A, High Lift Foam

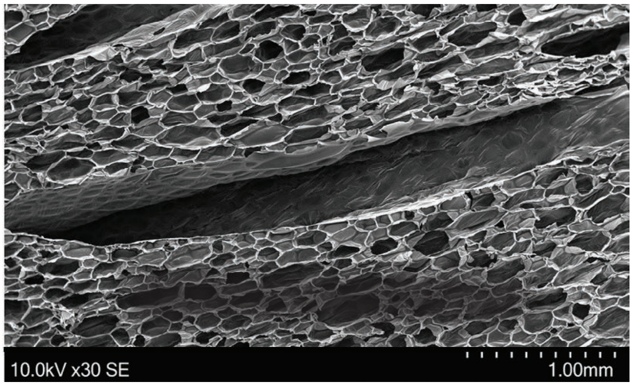


Figure 3*: Microscopic view of JM Corbond III (left). Microscopic view of Product A, high lift foam, and the resulting damage to the cellular structure as a result of the high lift installation (right).*

The lower density in the center of the sample, as seen on the right in Figures 2 and 3, is often also a sign that the closed-cell content and dimensional stability will be lower than expected, since these three properties are typically correlated. In the same high lift sample, a core specimen taken from the top 1-inch of the specimen (with skin removed) may have a closed-cell content similar, or equal, to the value marketed on the technical data sheet (TDS). However, the closed-cell content in a specimen taken from the center of the sample may be up to 40% lower than what is claimed. This occurs due to the poor stability of cell walls, which stretch and weaken as the foam is sprayed thicker and thicker. In serious cases, the cell walls may break, collapsing the core of the foam. This is very clearly shown in the center of the high lift sample (right) in Figure 2.

DIMENSIONAL STABILITY

The cell wall instability and weakness seen in Figure 2 can have serious real-world consequences for foam installed in attics, where temperature fluctuations throughout the year put greater stress on the foam than would be experienced in typical wall cavities. ASTM D2126 is the standard test method by which closed-cell foams are subjected to hot and humid aging to predict performance in real-world scenarios. The test subjects the foam to 168 hours (7 days) at 158°F and 97% relative humidity. Per the standard AC377, the maximum acceptable change in volume after this exposure is ±15%. When a foam fails ASTM D2126, it is most often recognizable as severe distortion of the spray foam sample after aging (Figure 4).

Product A, High Lift Foam

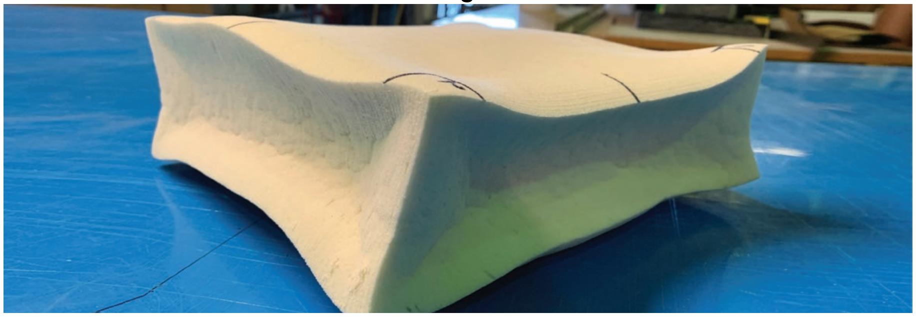


Figure 4*: A 5-inch sample of spray foam Product A that has undergone severe distortion as a result of the ASTM D2126 test method.*

When sprayed to thicknesses of 2-3 inches, the Product A high lift foam samples passed ASTM D2126. However, when tested at the manufacturer's recommended maximum lift thicknesses (4+ inches), the Product A high lift foam either failed AC377 standards or did not achieve the reported performance characteristics advertised in the manufacturer's technical data sheet.

The performance of Product A (single pass, 5 inches) in the ASTM D2126 test was subsequently compared to two different samples of JM Corbond III. The first sample of JM Corbond III was sprayed in a single, 5-inch pass to a total thickness of 5 inches; the second sample was sprayed in four, immediate, 1.75-inch passes to a total thickness of 7 inches. While it is not recommended to spray JM Corbond III in a single pass greater than 4 inches, for the purposes of comparative testing in this study, one of the JM Corbond III samples was sprayed, in a single pass, to 5 inches.

Each of these samples, Product A (single pass, 5 inches), JM Corbond III 5-inches (single pass), and JM Corbond III 7-inches (four, 1.75-inch immediate passes), was subjected to ASTM D2126 to explore how well the dimensional stability of the foam samples were able to withstand heat and humidity.

After completing the test, each of the product samples was removed from the humidity chamber and examined closely for distortion. The 5-inch, high lift Product A sample failed to meet AC377 requirements, exhibiting excessive distortion throughout the sample (Figure 5)

Product A, High Lift Foam

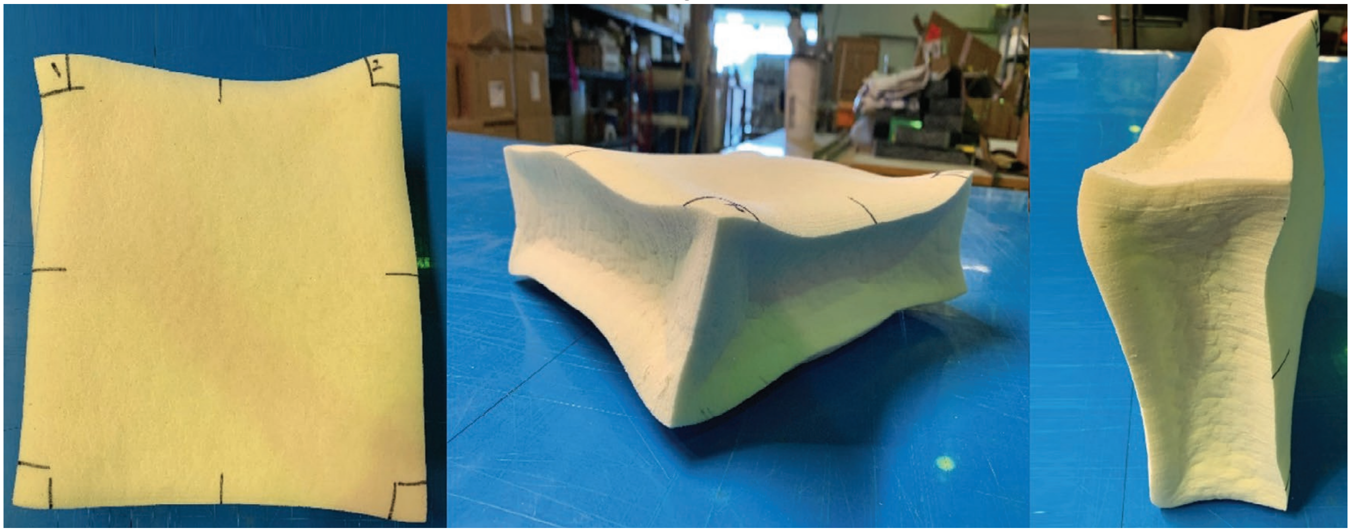


Figure 5*: Top and side views of the distorted, Product A high lift sample after ASTM D2126 testing.*

The distortion in Figure 4 and Figure 5 is apparent throughout the entire sample. Distortion this extensive in the real-world would likely cause the spray foam to separate from the surrounding structural supports, compromising the efficacy of the material, and potentially damaging the surrounding structures.

By comparison, the JM Corbond III sample sprayed in a single pass to 5 inches, exhibited slight distortion (~2%) on only one side (Figure 6, right), but otherwise retained its shape. It is worth noting that even though it is not recommended to spray JM Corbond III in a single pass greater than 4 inches, the 5-inch, single pass sample shown in Figure 6 also retained its shape and easily passed AC377 requirements.*

JM Corbond III (5-inch, single-pass*)

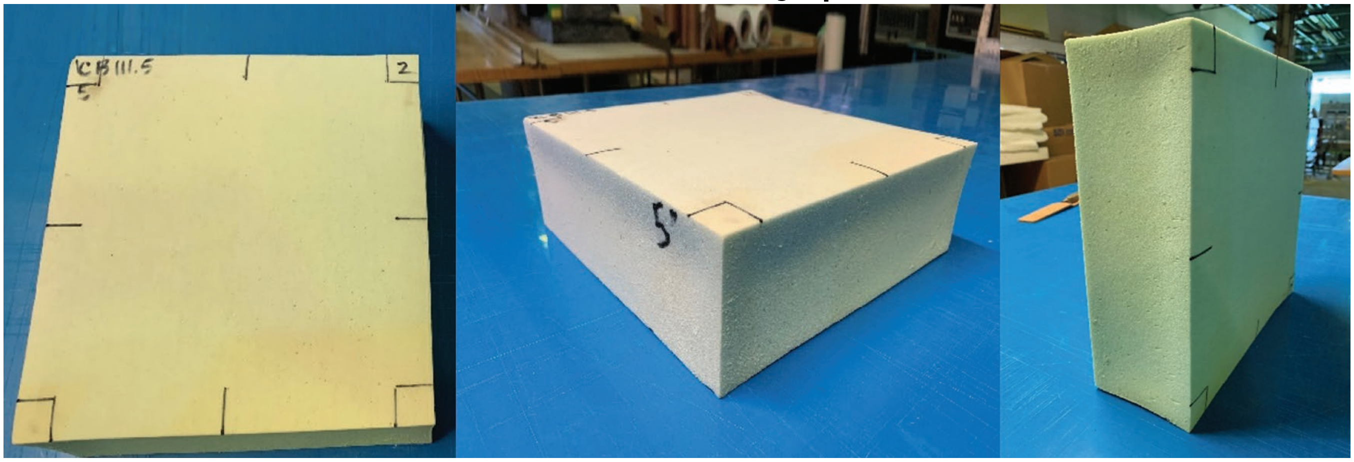


Figure 6: *5-inch single pass of JM Corbond III after ASTM D2126 testing.* The majority of the sample retained its exact shape, passing AC377, though a slight dimpling can be seen in the top of the sample in the image on the right. JM's installation instructions state that JM Corbond III closed cell spray foam should not be installed in single pass thicknesses greater than 4 inches. Please see the product installation guidelines for additional information.*

The consistency seen in Figures 6 and 7 is critical to ensuring that the spray foam will maintain its structural integrity during adverse environmental or weather conditions in an actual installation. Since spray foam is frequently installed in thicknesses greater than 5 inches, JM Corbond III was also tested under the same conditions at 7 inches thick, sprayed in four, immediate 1.75-inch passes. Figure 7 shows that even at 7 inches, the JM Corbond III did not warp or distort, despite being thicker than the Product A high lift sample in Figure 5.

JM Corbond III (7-inch, multiple-pass)

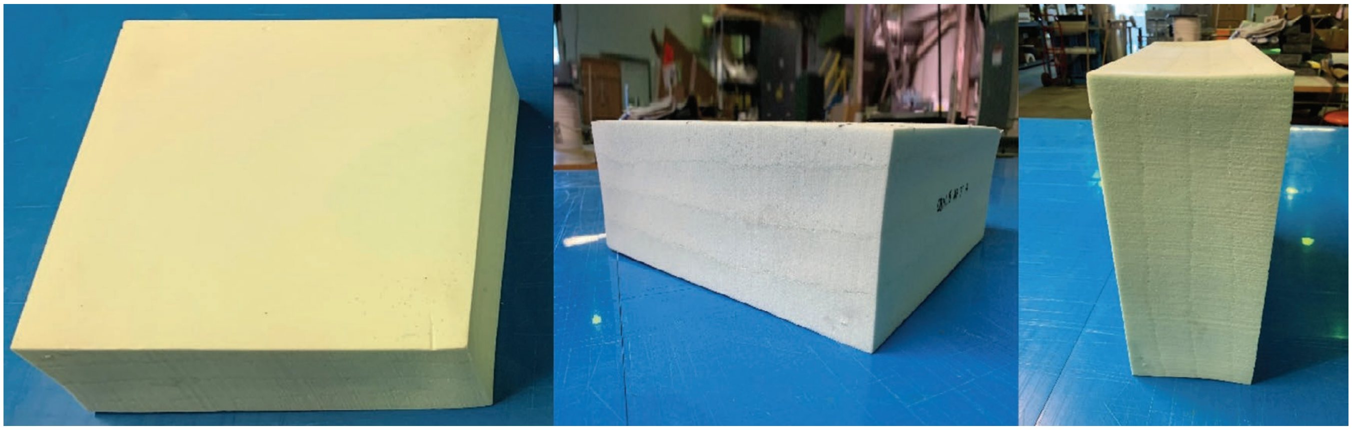


Figure 7*: Top and side views of the 7-inch sample of JM Corbond III, sprayed in four, immediate 1.75-inch passes after ASTM D2126, exhibiting no visual distortion and passing AC377.*

* When installing JM Corbond III, abide by the pass thicknesses outlined in Table One (on page 5) and in the Johns Manville Spray Foam Installation Guidelines. In the field, JM Corbond III should not be sprayed in single-pass thicknesses greater than 4 inches. This sample was sprayed in a 5-inch single pass for comparative purposes for this study only, and should not be replicated in an installation environment.

Despite being the thickest of the three samples, the multi-lift, 7-inch sample of JM Corbond III showed the greatest dimensional stability of all three product samples after testing. The differences in dimensional stability is perhaps most notable in Figure 8, where each of the three post-test samples can be seen side-by-side.

Left: JM Corbond III (7-inches) **Center: JM Corbond III (5-inches)** **Right: Product A (5-inches)**

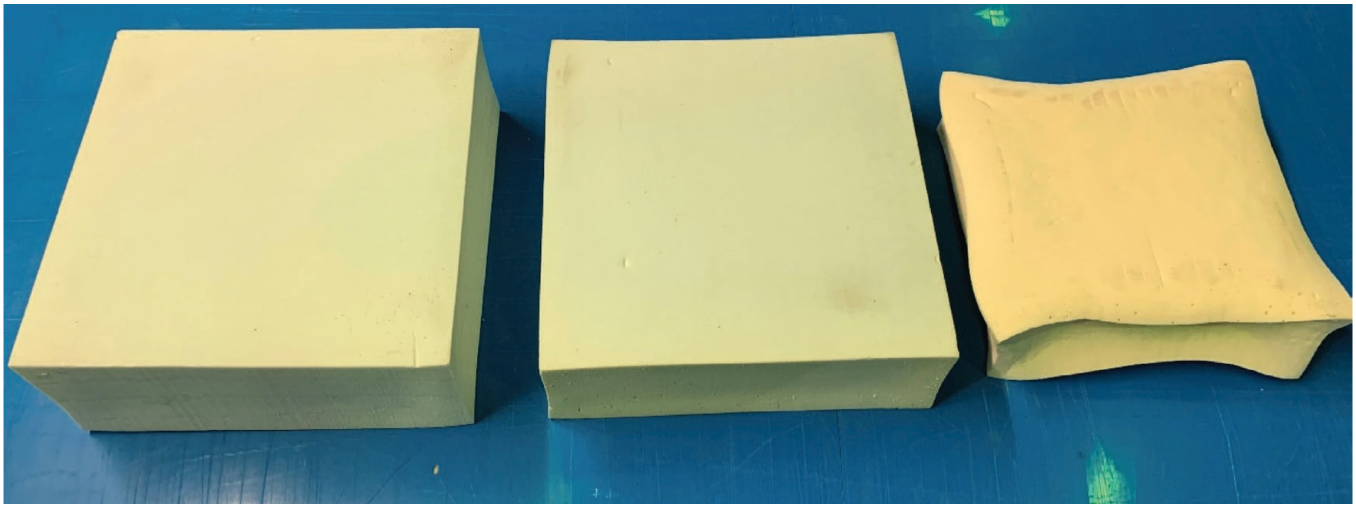


Figure 8: *Post ASTM D2126 test samples of spray foam from left to right. JM Corbond III 7-inches (sprayed in four, immediate 1.75-inch passes), JM Corbond III 5-inches (sprayed in a single pass), and Product A high lift (5 inches in a single pass).*

SUMMARY

When high R-values are required by codes or builder/owner preference, spray foam installers may choose to utilize a closed-cell product to cut down on installation time. However, as evidenced by the research outlined in this white paper, the manufacturer reported values on some high lift foams may have been extrapolated from test data resulting from thinner lifts rather than actual data from high lift testing. The physical performance characteristics of these foams may not perform as specified when used in thicker lifts, even when they are installed correctly per the manufacturer's guidelines.

In addition to the potential for inconsistent physical performance characteristics with a high lift spray foam, it is more difficult to correctly install a thicker lift of high lift spray foam (4+ inches) than it is to install a thinner lift of spray foam (4 inches or less). This combination of a difficult installation with inconsistent physical performance characteristics may result in poor performance by some high lift foams.

As such, it is recommended to contact the spray foam manufacturer and request their single pass, thick-sprayed test data for their advertised specification values to ensure the foam will actually perform as expected when installed as recommended. An alternative to contacting the foam manufacturer would be to install the high lift foam in thinner lifts and multiple passes. This may help protect the integrity of the physical performance characteristics of the spray foam material. However, many high lift spray foam insulations require cooling time between each lift to ensure they do not ignite during installation. Installers and specifiers should be aware of this before selecting a spray foam material as the required cooling time can negate the efficiency benefits achieved by using a high lift foam.

A second alternative to high lift foams is utilizing a material like JM Corbond III closed-cell spray foam, that can be sprayed safely in immediate passes without sacrificing the physical or performance characteristics of the insulation. This can allow installers to optimize their installation efficiency while maximizing the performance of the installed product without sacrificing safety.

Extensive testing has been performed to confirm the quality and safety of JM Corbond III sprayed in multiple immediate passes to achieve a thickness of up to 7 inches (R49). Table 1 shows the tested and recommended pass configurations that were subjected to and passed density, closed-cell content, and dimensional stability testing, as well as exotherm evaluations to confirm there is no risk for internal charring during cure.

Table 1: JM Corbond® III Recommended Immediate Pass Thicknesses

Passes	Pass Thickness	Total Thickness
1	4″	4″ (R28)
2	2.5″ + 2.5″	5″ (R35)
3	2″ + 2″ + 2″	6″ (R42)
4	1.75″ + 1.75″ + 1.75″ + 1.75″	7″ (R49)

Testing has verified that JM Corbond III will maintain its physical properties and performance characteristics when sprayed up to 7 inches in four immediate, successive passes with no wait time in-between. This allows installers to achieve an R-49, without compromising the integrity of the insulation while still capitalizing on the time-saving benefits of the immediate passes.

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