A BUYER'S GUIDE TO

RADIANT BARRIER & REFLECTIVE INSULATION FOR RESIDENTIAL ATTICS

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EXECUTIVE SUMMARY

This guide provides an analysis and evaluation of common radiant barrier and reflective insulation product types used for residential attic spaces. There are different styles and configurations of radiant barrier on the market, so to be representative of the market as a whole, one product representing each type was obtained and tested.

Each product was tested for initial emissivity, water vapor corrosion resistance, water vapor breathability, and tear strength. The specific test methods are referenced and described. On the basis of these tests, the product types are compared.

While all products had similar initial emissivities, there were bigger differences between the products in corrosion resistance, breathability, and strength. The results showed the following:

1. All of the products except for one showed a decrease in performance after exposure to water vapor, with the worst performing product corroding to the point it that it could no longer function as a radiant barrier.

2. All products except one failed to meet the minimum breathability requirement called out by building standards to reliably transmit water vapor, with the worst performing product acting as a vapor barrier despite its uniform perforations.

3. The reinforcement in the radiant barrier or reflective insulation makes a significant difference in terms of strength, but there is not necessarily a correlation between a product's strength and a product's thickness and/or weight.

While emissivity is arguably the most important characteristic of a radiant barrier or reflective insulation, it should be noted that even in the scope of radiant barrier and reflective insulation in a residential attic, there are differences in application and climate, where some of the other characteristics may be more or less important than others. For example, an attic floor application in a high-humidity climate may require less emphasis on strength and more emphasis on breathability and corrosion resistance.

This guide does not draw any conclusions of any product type being objectively better than any other in every instance or for every application, but rather serves the purpose of educating the readers and allowing them to make the best choice in product for their individual needs.

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INTRODUCTION

Radiant barrier and reflective insulation are types of insulation that work by reflecting and not emitting radiant heat, rather than transitioning the heat to conduction or convection to slow it. Many consider a product with additional insulation (like foam) inside the product to be a "reflective insulation" and the single-sheet products with no interior insulation to be a "radiant barrier;" however even a single sheet product can be a "reflective insulation" and get an R-value if installed across a dead air space, because the air itself can act as the insulation. Since the product designation is more application-specific rather than product-specific, we are including both in our guide.

There are many radiant barrier and reflective insulation products available online and on retail shelves. They all look similar enough: reflective surface on both sides, reinforcement in the center, perforations for breathability, etc. But don't be fooled into thinking that one is just as good as the other. There are actually very important differences between the products that may not be perceptible to the naked eye, and other differences that, while perceptible, may not be as important. To help buyers make a more informed decision, we sampled 5 products and tested for 5 different properties.

While many manufacturers test beyond the standards used in this guide, we chose 5 properties based on what we felt were most important to products themselves, the properties we believed consumers would be most concerned with, and finally, tests we felt would show the greatest difference between products. Not every possible test was run. Even some common tests were excluded because either all products appeared to perform equally, or the tests rely on subjective, visual inspection rather than objective, measurable data, but that doesn't mean manufacturer's shouldn't test to those other standards too. As a reference, you can consult ASTM C1313, "Standard Specification for Sheet Radiant Barriers for Building Construction Applications" or ASTM C1224, "Standard Specification for Reflective Insulation for Building Applications" for a list of all tests the products are recommended to meet. Of all the properties of radiant barrier and reflective insulation products that could be tested, we chose emissivity, corrosion, breathability, and strength (both tongue and trapezoid tear tests).

Of course, not every product on the market could be included in the guide. This is just a sampling and is not a complete list of all the products on the market. To alleviate the appearance of bias and to be fair to all manufacturers, we are not calling out specific manufacturers, brands, or products here, but rather giving a description of the products tested. Each of these products have been sold to consumers, whether through online distribution, retail stores, or through dealer networks. If one of the products we tested appears to be a product you have purchased or are thinking of purchasing, we recommend asking for the manufacturer's fact sheet or even the manufacturer's test reports themselves if you would like to compare. For this Buyer's Guide, we chose an aluminum foil/ foam/ aluminum foil, metalized film/ woven scrim/ metalized film, metalized film/ diamond scrim/ metalized film, aluminum foil/ woven scrim/ aluminum foil, and finally, a direct-metalized woven fabric product.

PRODUCTS

ALUMINUM FOIL/FOAM/ALUMINUM FOIL

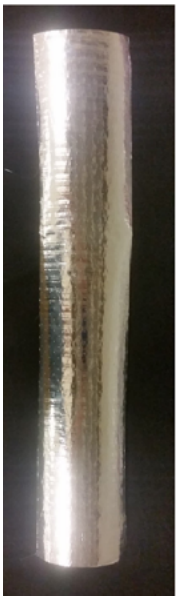
This was the only product type we included that had another insulation type as the interior reinforcement. While there are other products on the market that included insulation in its center (bubble packaging, fiberglass, cellulose, etc) most of those other products are intended to act as a vapor barrier and not be breathable. Since this foam product type included perforations, and since the intended application is the same as the thinner materials we tested, primarily as a radiant barrier in a vented attic space, we saw it fit to include. This product type is sold primarily through distribution, but may be available through other channels as well.

METALIZED FILM/WOVEN SCRIM/METALIZED FILM

This type of radiant barrier is probably the most prevalent among "DIYers" and contractor networks. There are many iterations of this type of product, some from American manufacturers and some imported from Canadian, Indian and even Chinese companies. The aluminized film on both sides looks mirror-like and appears to have very high reflectivity, and the thickness and weight of the product, along with the woven scrim, gives the appearance of high-strength. Considering the popularity of this type of radiant barrier and its perceived quality, no radiant barrier Buyer's Guide would be complete without it.

PRODUCTS

METALIZED FILM/DIAMOND SCRIM/METALIZED FILM



Whether shopping online or in big-box retail, this product type is generally the least expensive. The diamond pattern scrim looks similar to FSK (foil-scrim-kraft) insulation facer products, but it's important to note that FSK facer products are generally not perforated and not intended as a radiant barrier. The product type we tested here included no paper and used metalized film rather than an aluminum foil. The only apparent difference between this and the previously listed woven scrim product is the scrim itself, and at first glance one would assume that the only major difference between the two is strength; however the market price difference between the two is typically quite significant, so there may be other, more subtle, differences.

ALUMINUM FOIL/ WOVEN SCRIM/ ALUMINUM FOIL

This product type has attributes from two products we've already seen. The low emissivity surface is aluminum foil and the reinforcing scrim is a woven polymer. One would expect this product to have the strength of the Metalized Film/ Woven Scrim/Metalized Film and the emissivity and corrosion resistance of the Aluminum Foil/Foam/ Aluminum Foil. This product type seems to be the most popular among "do-it-yourself homeowners" and is sold direct-to-consumer from a few different online sellers. As such, it seemed appropriate that it be analyzed to give consumers a better sense of how it stacks up compared to the other products on the market.

DIRECT-METALIZED WOVEN FABRIC

Unlike all the other products in this guide, this material is not laminated at all. Instead the manufacturer describes a process of metalizing the woven reinforcement directly. The initial impression of the product is that it would be similar in strength to the Metalized Film/Woven Scrim/Metalized Film laminated product described above, due to the similar woven reinforcement, but the lack of films and adhesives makes the product thinner and lighter. Since only one manufacturer produces a product like this, it doesn't see the market share of its laminated competitor, but it is available online to homeowners and through direct distribution to contractors across the country. Due to the lighter weight and unique process of direct metal deposition, we suspected it might perform differently from other product types and therefore decided to include it.

EMISSIVITY TESTING

Since the single property that makes a radiant barrier or reflective insulation perform is its emissivity, it's fitting that this test be first on our list. Every object emits a certain percent of infrared heat and reflects a percent of infrared heat. Emissivity describes the amount of infrared radiant heat an object absorbs and emits, rather than reflects. Heat reflection and emission of products are not necessarily intuitive. For example, pure lead has an emissivity of 0.07 (or a reflectivity of 93%), and asphalt has an emissivity of 0.93 (or a reflectivity of 7%). Yet both products are essentially black.

Radiant barrier and reflective insulation products are often described in terms of reflectivity, or the percent of heat that is reflected. Since reflectivity is simply the reciprocal of emissivity, and it is emissivity that is actually measured in the test method, it makes more sense to describe the products to the exact property tested - emissivity. Another good reason to focus on emissivity as opposed to reflectivity, is that reflectivity can be used to describe different properties outside of infrared radiation that are irrelevant to this product type, like solar reflectivity and visual reflectivity, and may confuse the issue if the consumer isn't educated on the difference.

These products work by applying a low emissivity surface (0.1 emissivity or less) to a reinforced material and have that low-e surface face into an air space. When the material heats up (through conduction, convection or radiation), the low-e surface will only emit a small percentage of the heat into that air space. While radiant barrier and reflective insulation products are manufactured and specified to an emissivity of 0.1 or less, the exact emissivity can vary with the product. While we will be touching on emissivity as a measure of corrosion resistance later in the guide, what we are looking at here is the initial emissivity of the product straight out of the package. As an aid to those used to working in radiant reflectivity instead of emissivity, both are included below.

PRODUCT TYPE	EMISSIVITY	REFLECTIVITY
ALUMINUM FOIL/FOAM/ ALUMINUM FOIL	0.035	96.5%
METALIZED FILM/WOVEN SCRUM/METALIZED FILM	0.050	95%
METALIZED FILM/DIAMOND SCRIM/METALIZED FILM	0.030	97%
ALUMINUM FOIL/WOVEN SRIM/ALUMINUM FOIL	0.035	96.5%
DIRECT-METALIZED WOVEN FABRIC	0.040	96%

EMISSIVITY TESTING

The emissivity was tested according to ASTM C1371, "Test Method for Determination of Emittance of Materials near Room Temperature Using Portable Emissometers." This method takes a random sampling of each material and, using a small tabletop device, emits heat onto the product with a heat sink below and measures the amount of infrared heat that emits through.

While the ASTM C1371 emissivity test doesn't designate a pass/fail criteria, ASTM C1313, "Standard Specification for Sheet Radiant Barriers" does define a radiant barrier as a material having an emissivity of 0.1 or less. All products tested above met this minimum criteria and can be called a radiant barrier. Outside of that, the emissivity test is best used to compare the performance of the products to each other.

While the results were, for the most part, what one would expect from a radiant barrier or reflective insulation, there are a couple of interesting things to note:

1. Products that look the same can have very different emissivities. The highest performing (lowest emissivity) was the Metalized Film/Diamond Scrim/Metalized Film product with an emissivity of 0.03, while the lowest performing (highest emissivity) was the Metalized Film/Woven Scrim/ Metalized Film product. The metalized films on these two products look identical to the naked eye, which just goes to show that emissivity is not a property that can be accurately estimated by sight. In fact, the performance of the duller-looking aluminum foil had the median emissivity. Just because a product "looks more reflective" doesn't necessarily mean its infrared reflectivity is any higher or its emissivity is any lower.

2. The emissivity of both aluminum foil product types were both 0.035, and while that fact that they are the same is to be expected, it is surprising that they are both higher than 0.03, which is what aluminum should be. The manufacturers and distributors of this product type all advertise 97% reflectivity (0.03 emissivity), and while the difference may not seem significant, it is something the the manufacturers, distributors and consumers should be aware of. While we can only speculate on the reason for the higher emissivity, it may be that the foil used is less than "pure" aluminum, or it may be that the foil has been sitting out exposed to oxygen and humidity in the air and has already started to corrode. We will explore the effects of corrosion in the next section.

CORROSION TESTING

Since emissivity is so important to the performance of a radiant barrier or reflective insulation product, it makes sense that manufacturers would want to ensure the emissivity would last. Since traditionally radiant barriers and reflective insulations have used aluminum, which is a reactive metal that corrodes especially easily in water, the corrosion tests performed usually involve exposing the material to high temperatures and high humidity levels over time to get a sense for how the product will hold up to heat and humidity, or "corrosion resistance".

ASTM C1313 recommends testing radiant barriers to ASTM D3310, "Standard Test Method for Determining Corrosivity of Adhesive Materials," which involves putting a small sample of the material in a jar with water and putting the sealed jar in an oven set at 71 degrees C for 7 days. After the 7 days, the material is visually inspected for signs of corrosion. The results are rated on a scale of 1 to 5.

ASTM C1224 recommends testing reflective insulations to ASTM C1258, "Standard Test Method for Elevated Temperature and Humidity Resistance of Vapor Retarders for Insulation," which involves putting samples of the material in an environmental chamber set to 49 degrees C and 95% relative humidity. This test is arguably as aggressive as the ASTM D3310 because it simply lowers the temperature and takes place over a longer period of time.

However, there are two problems associated with these tests being applied to radiant barriers and reflective insulations. First, the above tests are not nearly aggressive enough to show significant differences between products. We need an environment harsh enough to noticeably affect the products. Second, and this is particularly important for this type of product, a visual inspection rating is both too subjective and a poor unit of measure, as emissivity is the primary indicator of performance.

As an objective comparison between the products, each sample was suspended over 90 degree C water (100% relative humidity) for 15 minutes. Due to the high temp and humidity level, 15 minutes was all it took take to noticeably corrode samples. We then used emissivity testing to numerically determine how much each product had been affected.

CORROSION TESTING

Both as a reference to compare the performance lost due to corrosion and to compare corrosion resistance across products, the results below show the emissivity of each product both before and after corrosion testing.

PRODUCT TYPE	INITIAL EMMISSIVITY	INITIAL REFLECTIVITY	POST-CORROSION EMMSSIVITY	POST-CORROSION REFLECTIVITY
ALUMINUM FOIL/ FOAM/ ALUMINUM FOIL	.035	96.5%	0.080	92%
METALIZED FILM/ WOVEN SCRIM/ METALIZED FILM	0.050	95%	0.078	92.2%
METALIZED FILM/ DIAMOND SCRIM/ METALIZED FILM	0.030	97%	0.372	62.8%
ALUMINUM FOIL/ WOVEN SCRIM/ ALUMINUM FOIL	0.035	96.5%	0.07	93%
DIRECT-METALIZED WOVEN FABRIC	0.040	96%	0.037	96.3%

There are two things that really jump out from these results:

First, that the Direct-Metalized Film product actually improved. Since it's impossible for the emissivity of aluminum to be lowered with exposure to conditions designed to corrode metals, the decrease in emissivity of the Direct-Metalized Woven Fabric is likely due to the test method having a margin of error of at least 0.003. This also means that the Metalized Film/ Woven Scrim/ Metalized Film could have performed better or worse than the Aluminum Foil/ Foam/ Aluminum Foil product.

Second, due to the dramatic increase in emissivity of the Metalized Film/ Diamond Scrim/Metalized Film combined with the fact that the product started off at 0.030 emissivity (the textbook emissivity of pure aluminum), one could draw the conclusion that the product was totally uncoated and unprotected from the effects of high temperature and humidity. ASTM C1313 defines a radiant barrier as having an emissivity of 0.1 or less, so the Metalized Film/Diamond Scrim/ Metalized Film product would be **no longer considered a radiant barrier** after corroding like this.

CORROSION TESTING

If results like these arose in the field, the product would need to be uninstalled and replaced with a product that would still work as a radiant barrier.

The Aluminum Foil/Foam/Aluminum Foil and the Aluminum Foil/Woven Scrim/ Aluminum Foil changing very little despite starting off at a lower emissivity is not surprising though. When aluminum corrodes, aluminum oxide is formed over the surface. Since aluminum oxide is higher emissivity but generally transparent, the emissivity of the material is determined by what is underneath the aluminum oxide layer. Since aluminum on metalized film is just nanometers thin, much of the aluminum oxidizes, leaving just the high-emissivity polymeric film below. Aluminum foil, however, is microns thick, so even after aluminum oxide builds on the surface, there's still aluminum foil exposed underneath. **One would expect similar results from any product using aluminum foil rather than metalized film.** The foil products starting with identical emissivities but having different post-corrosion emissivities may be explained by factors like different thickness of foil, which could provide additional barrier to oxidation, or differences in the perforations, which may allow the moisture better access to deeper layers of the foil.

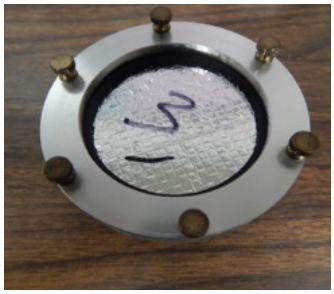
The increase in emissivity on unprotected aluminum can be quite pronounced. In fact, the corrosion test described here isn't as aggressive as testing that has been conducted with liquid water instead of water vapor. ASHRAE, which gives emissivity and R-values of various insulation materials for the building and HVAC industries, lists the average emissivity of aluminum foil with visible condensation as 0.30 (70% reflective) and the emissivity of aluminum foil with condensation "clearly visible" as 0.70 (30% reflective).

While admittedly our testing isn't as aggressive as what ASHRAE describes, our results indicate that a vacuum metalized film or fabric has the potential to hold up better to corrosion than an aluminum foil, as the Direct-Metalized Woven Fabric product type was unchanged while the aluminum foil product types increased in emissivity by over 2X. Although, clearly not all coatings work the same, as the Metalized Film/ Woven Scrim/ Metalized Film performed on par with the foils. **Of course, all of these options are still preferred to an uncoated metalized film.**

BREATHABILITY TESTING

While there are certainly applications where radiant barrier and reflective insulation products are used as vapor barriers or vapor retarders, like in sealed crawlspaces and basements, or behind the drywall in cold climates, the predominant installation of residential radiant barrier and reflective insulation applications is in a vented attic space in a warm climate. When installed in applications like over the insulation on the attic floor, stapled to the underside of the roof decking, or across insulated knee walls, it is imperative that moisture vapor be allowed to escape the living space and attic insulation, and exit through the roof ventilation.

Both ASTM C1313 and ASTM C1224 state that any product designed to be a vapor retarder may not exceed 1 perm, and a product designed to be vapor permeable should exceed 5 perms when tested to Procedure A of ASTM E96, "Standard Test Methods for Water Vapor Transmission of Materials."



Procedure A of the ASTM E96 test method seals a sample of the material over the top of a small cup, which has been partially filled with a moisture-absorbing desiccant at a steady atmospheric temperature and humidity level. The samples are then removed, and the moisture absorbed through the tested material into the desiccant is measured. ASTM E96 gives this measurement both in grams per square meter per 24 hours, and more simply, in units called perms.

Just because a product is perforated doesn't mean it's breathable. In 1992, The University of Minnesota conducted a study on the performance of a radiant barrier in a cold climate. They ran into a problem with the experiment due to their perforated radiant barrier not being breathable enough. *"The perforations of the radiant barrier used in this study did not allow adequate amounts of water vapor to escape from the thermal envelope as conditions got colder. Consequently, moisture/frost formed on the underside of the radiant barrier."* If it could happen to PhDs, it could happen to you.

Since each manufacturer uses their own perforator, which may be customized for their own product, some products have larger holes further apart and some have smaller holes closer together. Since all we are concerned about here is the ability for water vapor to breath through the product, the perforations don't necessarily need to be large enough for liquid water or even fast moving air to pass through. Therefore, much like the emissivity, the breathability of the material is difficult to judge with the naked eye.

Considering the importance of moisture escaping the home, and the fact that some radiant barrier and reflective insulation manufacturers choose not to list the breathability of their products, we felt this material property warranted testing. To further improve the accuracy, each product was tested 3 times and the average was taken.

BREATHABILITY TESTING

PRODUCT TYPE	TEST 1	TEST 2	TEST 3	AVERAGE
ALUMINUM FOIL/ FOAM/ ALUMINUM FOIL	12.3 PERMS	2.4 PERMS	0.0 PERMS	4.9 PERMS
METALIZED FILM/ WOVEN SCRIM/ METALIZED FILM	0.9 PERMS	0.6 PERMS	1.5 PERMS	1.0 PERMS
METALIZED FILM/ DIAMOND SCRIM/ METALIZED FILM	4.2 PERMS	5.4 PERMS	5.4 PERMS	5.0 PERMS
ALUMINUM FOIL/ WOVEN SCRIM/ ALUMINUM FOIL	3.3 PERMS	4.5 PERMS	4.2 PERMS	4.0 PERMS
DIRECT-METALIZED WOVEN FABRIC	6.0 PERMS	8.1 PERMS	6.6 PERMS	6.9 PERMS

When looking at the final averages, you'll notice that most of the numbers are quite low. It's unclear whether this is a flaw in the product types themselves (perhaps the material is too puncture resistant) or an oversight by particular manufacturers (perhaps ones that need to buy new pins). ASTM C1313 and ASTM C1224 state that a product intended to be a barrier to water vapor shall not exceed 1 perm. By this standard, the Metalized Film/Woven Scrim/Metalized Film product could be considered a vapor barrier. For a product that is perforated and sold as breathable and safe for the home, it raises serious concerns. **One would hope that this is an isolated incident with a manufacturer and not endemic problem with the product type.**

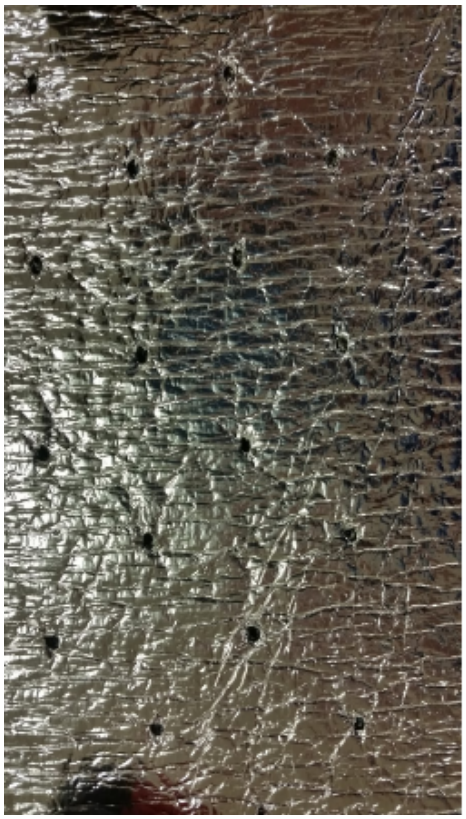
Three other products were still not quite breathable enough to meet the standard for a product intended to be vapor transmitting. ASTM C1313 and ASTM C1224 state that "the material shall exceed 5 perms." The Aluminum Foil/ Foam/ Aluminum Foil product was measured at 4.9 perms, the Aluminum Foil/ Woven Scrim/ Aluminum Foil product was measured at just 4.0 perms, and the Metalized Film/ Diamond Scrim/ Metalized Film was measured at 5.0 perms. The consumer should be cautions of these products, since they fall under the breathability recommended by building standards. Homeowners may want to look for signs of moisture accumulation in any areas where these products are installed, especially when it gets cold outside.

There are a number of reasons for products getting a lower perm rating that they should. When a material is perforated with pins, it's not uncommon for certain pins to be duller than others or even become duller over time, or when perforating a material that is particularly elastic, for the holes to start to close after the pins have passed through. Additionally, the pattern of the perforations and the random selection of samples for the test may play a part.

BREATHABILITY TESTING

For the most part, each of the three tests performed on the products fell in line with the kind of variance to be expected in the test, that is, all products except the Aluminum Foil/Foam/Aluminum Foil. The deviations between the Aluminum Foil/ Foam/Aluminum Foil were troubling, and well outside of the norms of the test. Upon closer inspection, the thick foam in the center may be to blame. The foil on one side shows large holes clearly poking in, but the foil on the other side shows much smaller holes, and in some cases, no holes at all. When breathability is good (big holes all the way through) it's nearly twice as breathable as any other product tested, but when the holes don't go all the way through, the product is practically a perfect vapor barrier. The average came out to the product not being quite breathable enough.

The photos below depict two sides of the Aluminum Foil/ Foam/ Aluminum Foil product. Notice the lack of holes in the second picture that are visible in the first picture. This explains why one of the tests showed this product at 12.3 perms for one test and 0.0 perms in another test. It all depends on what area of the product was tested.

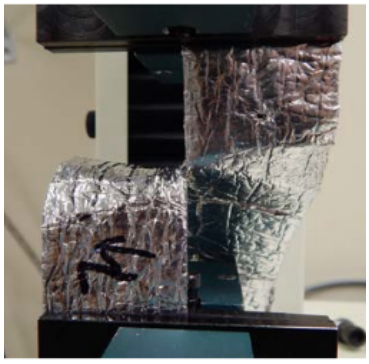


STRENGTH TESTING

Just as we discussed in the previous section on breathability, the strength you need will depend on the application. While installing radiant barrier or reflective insulation on insulation on the attic floor or installing it under a subfloor may not require very high strength at all, other applications like installing it between trusses in a roof or across joists in a crawlspace, will require the material to be strong enough to hold staples (or nails with washers) and be able to be pulled tight without ripping or tearing.

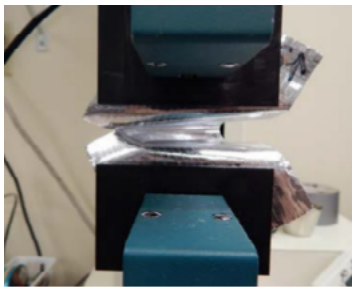
Different products achieve strength in different ways. Products that use a metalized film or aluminum foil typically laminate their film or foil on both sides of a reinforcing scrim. This scrim may consist of thin polyethylene, polyester, nylon or fiberglass threads that cross in a grid pattern. A higher-strength scrim may use a woven fabric, which is higher cost than the nonwoven varieties but can achieve over 10X the strength. The only product made without laminating a film or foil to a scrim is the Direct-Metalized Woven Fabric product we tested. This product is unique (and patented) and therefore isn't as prevalent as the other product types, which have many look-alikes.

Unlike emissivity, the scrim is something that can be seen by the naked eye, and the product is often judged on that basis. While it may be tempting to look at a laminated product with a scrim and make the assumption that the thicker or heavier it is, the stronger the product will be, this is not always the case. It may be a general rule of thumb for products that are identical in all other respects, but some products may break this rule. Laminated products can manipulate your perception because the thickness of the adhesive between the laminated layers or thickness film or foil doesn't add strength but still make the product thicker and heavier. That is why it is still important to do an official strength test.



The test called out in ASTM C1313 is the test method ASTM D2261, "Test Method for Tearing Strength of Fabrics by the Tongue (Single Rip) Procedure (Constant-Rate-of-Extension Tensile Testing Machine)." First the tester initiates a tear in the material. The machine then pulls the material to propagate the tear and determines how much pressure is required to tear the product 3 inches. The test is run in two directions, machine direction and cross direction, and an average of the 5 highest peaks (measured in force) are given.
Although it is called out in the radiant barrier standard specification, it really gives best results to materials that are more stiff and rigid (as opposed to materials that stretch).

STRENGTH TESTING



Since the Direct-Metalized Woven Fabric product is not a stiff, laminated, but rather a thin, pliable fabric, we had concerns about it stretching (rather than tearing) under the stress of the test and throwing off the results. To make sure we were getting a fair comparison between products, we also included a strength test specifically designed for non-laminated fabrics, ASTM D4533, "Standard Test Method for Trapezoid Tearing Strength of Geotextiles." While the test itself is similar to the previous test, the rig used in ASTM D4533 controls the path of the tear along a diagonal guide. This means that more threads in the reinforcement are likely to break, and the stretch along the threads is minimized.

	TONGUE TEAR METHOD		TRAPEZOID TEAR METHOD	
PRODUCT TYPE	**MACHINE DIRECTION**	**CROSS DIRECTION**	**MACHINE DIRECTION**	**CROSS DIRECTION**
ALUMINUM FOIL/ FOAM/ ALUMINUM FOIL	2.22	1.08	3.57	1.94
METALIZED FILM/ WOVEN SCRIM/ METALIZED FILM	15.35	10.73	9.64	9.98
METALIZED FILM/ DIAMOND SCRIM/ METALIZED FILM	2.88	1.92	6.33	5.77
ALUMINUM FOIL/ WOVEN SCRIM/ ALUMINUM FOIL	35.38	35.53	37.20	37.90
DIRECT-METALIZED WOVEN FABRIC	17.99	14.69	28.39	16.54

The strongest product tested, across both tests, was the Aluminum Foil/ Woven Scrim/ Aluminum Foil, and the next strongest product was the Direct-Metalized Woven Fabric. Aside from the Aluminum Foil/ Foam/ Aluminum Foil, which proved to not be very reinforced at all, the Aluminum Foil/ Woven Scrim/ Aluminum Foil was the thickest, and the Direct-Metalized Woven Fabric was the thinnest. If thickness alone was an indicator of a product's strength, one might assume that the Direct-Metalized Woven Fabric would be the weakest rather than the second strongest.

STRENGTH TESTING

The testing results also show that our concerns about the Direct-Metalized Woven Fabric product being at an unfair disadvantage were unwarranted. While the numbers were improved under the ASTM D4533 test, it was still was the second highest performer. Since the purpose of this Buyer's Guide is to simply compare product types, the exact numbers are less important than the rankings of the products and understanding the differences in how they perform, especially in a test with no pass/fail criteria. In each test, the product rankings themselves remained unchanged.

One result that was not expected was that the Metalized Film/ Diamond Scrim/ Metalized Film performed significantly better (over 2X) in the ASTM D4533 trapezoid test than the ASTM D2261 tongue tear test. There may be a couple reasons for this.

1. While the Metalized Film/ Diamond Scrim/ Metalized Film product is laminated, it is not as stiff as the other laminated metalized film or aluminum foil products. The yarns of the scrim could be moved and stretched within the material, allowing it to flex and stretch to a certain degree.

2. Additionally, the threads are running diagonally rather than in the machine and cross direction of the product, so perhaps the ASTM D4533 trapezoid tear test was a more representative test of the material in so far as getting an apples-to-apples comparison between the strength of the reinforcing scrims.

Despite all this testing and analysis over the exact numbers and why they are what they are, we still aren't shown what really matters in terms of strength. While the test results give us an indication of which type of product is weaker or stronger than another, the end use of these products isn't to be fastened to a machine and pulled in the machine or cross direction; they are to be installed in a residential attic. Some applications may not require much strength at all, and even the ones that do, only require the product to be able to hold staples at most.

This is another case where consumers, seeing very little difference between the products, hone in one one of the few differences they do see (like scrim pattern, thickness, or weight) when some of the product attributes they can't see (like emissivity, corrosion resistance, or breathability) are far more important.

CONCLUSION

There are many factors that go into manufacturing a high quality radiant barrier or reflective insulation. Attributes like emissivity, corrosion resistance, breathability, and strength, are important for any radiant barrier or reflective insulation product, and should be tested on a regular basis to ensure the product is consistently performing.

Manufacturers, importers, and even private-label distributors should be more aware of the testing and requirements of radiant barriers and reflective insulations. More than just sending samples and a money order to a testing lab and getting back numbers (although they should absolutely do that), they also they need to understand what the results mean and why they are important.

For distributors or installers, this Buyer's Guide may help you choose the type of product right for you or even just give you more to think about when making your decision. But even if the specific product type you're looking for wasn't included above, at least you should know what specifications to look for and what kinds of questions to ask.

While there were many conclusions that could be drawn from the testing we conducted, the big standouts were:

1. The lack of differentiation in initial emissivity, and but big differences in emissivity after corrosion showed how important the coating on the exterior surface really was. All the materials except for one showed a decrease in performance after corrosion, with one losing so much that it could no longer be classified as a radiant barrier.

2. The perforation patterns and perm ratings were all different and seemed unique to, if not customized for, each specific product, and yet most of the products couldn't meet the minimum breathability requirement called out by building standards to reliably transmit water vapor.

3. While different strength tests did produce different results, demonstrating that some product types are stronger under different circumstances, both tests allowed for a reliable ranking of the products by strength.

Just as a reminder, while the specific products tested have in fact been sold into the market, the intent of this guide is not to call out any one specific product or brand, but rather to compare categories or types of products with different physical properties and see how they measure up to each other. While there may be some variability in the testing results between different products within a single product type, it is reasonable to assume that all products within a product type will perform more similarly to each other than to products in a different product type. To learn more about radiant barriers, reflective insulations, their standard specifications, their testing methods, or anything else discussed in this Buyer's Guide, you may consult the full versions of the documents referenced.

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