

VAPOR PERMEABILITY PROVIDES **NO PERFORMANCE BENEFIT FOR ROOFING UNDERLAYMENTS** IN VENTILATED ATTICS

**Testing Shows Breathable
Underlayment Provides
Little or No Moisture
Transfer Value in Asphalt
Roofing Systems**

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June 2011



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Abstract

Many manufacturers have introduced synthetic underlayments in the roofing market to serve as secondary water shedding barriers under roof shingles. Traditional organic asphalt felt has served this purpose for years, but durability has diminished over time and the product is inferior to recently available synthetic products made with layers of composite polyolefin. While traditional felts are permeable, allowing moisture vapor transfer over time, newer synthetic materials are typically nonpermeable, allowing very little moisture transport.



Figure 1: Typical Underlayment Installation



Recent testing and evaluation at Owens Corning demonstrates that “adding” breathability to synthetic underlayment provides no advantage to the building performance of an asphalt roof assembly.

A modified ASTM E 96 “Dry Cup” testing method demonstrated that standard overlapping shingle construction creates its own vapor barrier system, preventing both the transport of moisture from exterior weather elements, as well as preventing moisture vapor escape from the building interior. Moisture transfer through the roof cannot be achieved simply by making the underlayment material breathable. Because the experimental data indicates that the multi-layered shingle system creates a vapor barrier, a properly designed and installed attic ventilation system, or a properly designed and installed unvented roof assembly¹, is necessary to protect the roof sheathing from moisture within the home.

“ *The focus of this paper is to investigate the system performance of standard asphalt shingles and to evaluate the impact of installing nonbreathable underlayments.* ”



The focus of this paper is to investigate the system performance of standard asphalt shingles and to evaluate the impact of installing nonbreathable underlayments between the shingle layer and the roof deck. The research performed indicates that nonbreathable underlayments may be installed below asphalt shingle roofing materials with comparable or better moisture performance.

¹ For Owens Corning Roofing and Asphalt, LLC’s position on Unvented Attics see Technical Services Bulletin RD-01012011. Request by phone: 1-419-248-6557 or e-mail: gettech@owenscorning.com.



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Introduction

The roofing market has seen an onslaught of new synthetic underlayment products in the past 10 years. These products bring many advantages to the installer: increased speed of installation; lighter weight; and significantly stronger physical characteristics, resulting in increased wind uplift performance than typical asphalt felt underlayment. These products also benefit homeowners by protecting their homes as a durable moisture barrier from the elements over an extended period of dry-in during construction or re-roofing.

Some synthetic products claim to improve performance of the roofing system by including “breathability” as an added feature. But does this feature truly add any benefit to a typical asphalt shingle roofing system?

In a typical installation, underlayment is sandwiched between the plywood or oriented strand board (OSB) roof deck and a covering layer of asphalt shingles.

“Some synthetic products claim to improve performance of the roofing system by including ‘breathability.’”

Does a breathable underlayment allow attic moisture to escape? Does it allow a roof deck to breathe? These questions are addressed in this white paper.





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Defining Breathability

The 2009 International Residential Code (IRC) defines a vapor permeable membrane as “a material or covering having a permance rating of 5 perms or greater, when tested in accordance with the desiccant method with Procedure A of ASTM E 96. A vapor permeable material permits the passage of moisture vapor.”²

However, traditional convention within the building industry defines:

- a material with a perm of less than 0.1 as vapor impermeable
- a material with a perm of between 0.1 and 1.0 as vapor semi impermeable
- a material with a perm of between 1.0 and 10.0 as vapor semi permeable
- and a material with a perm of greater than 10 as vapor permeable

Additionally, a vapor barrier is defined as less than 0.1 perm and a vapor retarder is defined as less than 1.0 perm. As such, some inconsistency exists between the IRC and traditional convention.

Measuring Permeability

The industry standard test method for water vapor transmission, also known as permance, is ASTM E 96–Standard Test Methods for Water Vapor Transmission of Materials.³ Because the IRC recommends the “Dry Cup” process defined as Procedure A, and with consideration of the sample size required to examine the overall system effectively, the dry or desiccant method was used for the shingle roofing system testing in this study.

“The industry standard test method for water vapor transmission, also known as permance, is ASTM E 96–Standard Test Methods for Water Vapor Transmission of Materials.”

The test is relatively straightforward. Test material is sealed over a container of desiccant and placed in a humidity- and temperature-controlled chamber. Over time, the desiccant will draw moisture from the ambient air in the chamber through the test material, which is then trapped in the desiccant. Measuring the water weight-gain in the sealed container over time gives a value for permance, which measures the time rate of water vapor transmission through the test material.



Figure 2: #15 Felt Underlayment Sample–ASTM E 96–6" dia. “Dry Cup”



² International Residential Code for One- and Two-family Dwellings, First Printing: March 2009, Copyrighted 2009 by International Code Council, Inc., Publications, 4051 West Flossmoor Road, Country Club Hills, IL 60478-5795.

³ ASTM E 96.

Individual Component Testing

ASTM E 96 enables the measurement of individual materials as well as the assembled system. Individual material testing was accomplished using 6" cups with a wax seal ring around the perimeter to close the sample cup. Table 1 provides a baseline understanding of the roofing system materials.

Table 1: Typical Single Component Testing ⁴	
TEST MATERIAL	PERMEANCE RATING
Asphalt Shingles–Individual	0.9
#15 Felt	7.0
Breathable Synthetic	9.5
Nonbreathable Synthetic	0.1
7/16" OSB Decking	1.0

Shingle Installation Instructions

Owens Corning™ Classic® 3-tab shingles were used in all testing. Application instructions for these shingles include a 5" vertical exposure on the 12" high shingle and a 6" offset on the horizontal dimension for shingle lapping. This is the industry standard practice for shingle installation.

This method provides an overlapping “water shedding” construction necessary to keep rainwater out. The same principle greatly increases the travel path or flow length for air movement through the same assembly. This resistance to airflow is likely the greatest contributing factor in creating the vapor resistance which this testing demonstrates.

With a 12" height and a 5" exposure on the individual shingles, the overlapping system results in air path which always has a double layer of shingles, and a triple layer of material at each vertical intersection for air and moisture vapor to migrate through. The 36" width on the shingles also introduces a complicated path for any air and moisture vapor to travel through in the horizontal—or lateral—direction. Additionally, shingles are relatively heavy and flat and have a rough surface, all three of which are physical characteristics that increase the resistance to airflow in the roofing system.

“Resistance to airflow is likely the greatest contributing factor in creating the vapor resistance which this testing demonstrates.”

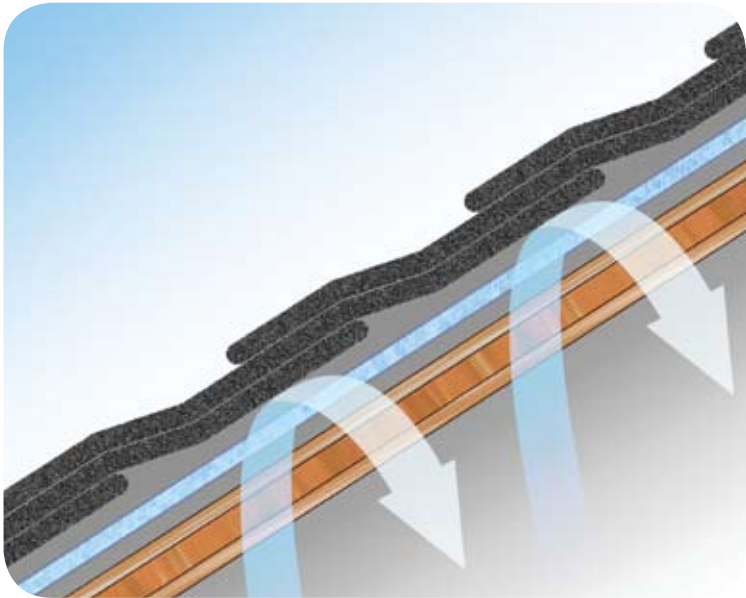


Figure 3: Overlapping Shingle Construction

⁴ ASTM E 96 Sect. 11, Procedure for Desiccant Method.

Roofing Shingle Layer Testing

A 24" wide by 36" long commercially available plastic pan was selected as the "test dish" for the ASTM E 96 testing on large-scale system components. This size allowed for a typical asphalt shingle application with seven overlapping horizontal rows of shingles, and three vertical butt joints between adjacent shingles. To simulate the shingle layer during application, an OSB frame was fabricated with large slotted windows to allow moisture vapor transfer through this layer with minimal interference from the OSB, while the OSB allowed the shingle attachment as per manufacturer's instructions.

Repetitive testing on this application showed the multi-layered asphalt shingle system—when installed per the manufacturer's instructions—has an average moisture vapor transfer rate of 0.65 perms. Demonstrating a measured perm of less than 1.0 showed that moisture transfer through the multi-layer asphalt shingles is negligible.



This important fact begs the question: If the asphalt shingles act as a vapor retarder on the roof, then what value is added with the introduction of a breathable roof underlayment below it? Any moisture within the roof deck or the attic will not be able to move through the roofing system, regardless of the permeability of the roofing underlayment layer.

“ A measured perm of less than 1.0 showed that moisture transfer through the multi-layer asphalt shingles is negligible. ”

Computer Analysis

Using a state-of-the-art hygrothermal (combined heat and moisture transport) model developed by Karagiozis *et al* (2001), two simulations were performed representing the impermeable and permeable underlayment. This model has been validated for a number of wall and roof systems showing good agreement with field data by a number of organizations. These two simulations were performed to investigate the moisture storage differences between the two types of roof underlayment approaches. Figure 4 indicates that there is no apparent difference in the manner water vapor transport is managed across these two different underlayment systems. Follow-up simulations showed, if time-aged roof shingles deteriorated and water penetration occurred onto the underlayment, substantially higher moisture accumulation in the OSB occurred for the vapor permeable underlayment.

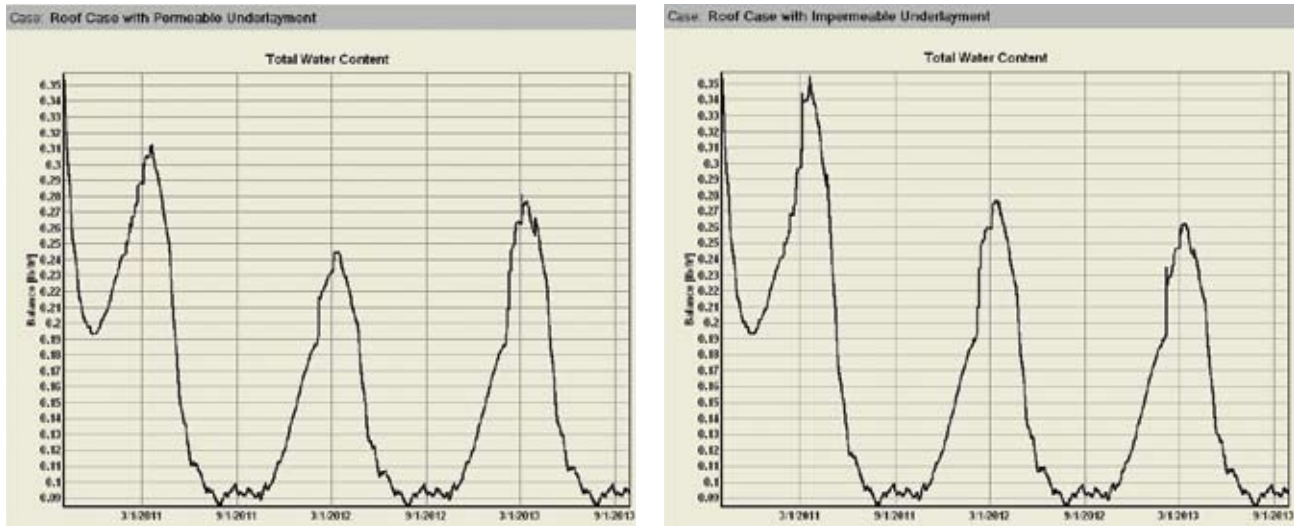


Figure 4: Hygrothermal Simulations Validating the Hypothesis

Validation – Initial testing used $\frac{7}{16}$ " OSB and Owens Corning™ *Classic* 3-tab shingles on each sample, with 3 different underlayments: standard 15-lb. felt, Fiberglas® Reinforced Felt and a nonbreathable brand of synthetic underlayment, using three full-system boards for each test.

This testing validated the initial computer model, but additionally it drove further testing on the individual components. Part of this was the testing of the shingle overlap layer which was discussed earlier, but additionally it validated the large-scale test specimen developed to facilitate the testing.

Table 2: Initial Roofing System Testing

TEST MATERIAL	PERMEANCE RATING
OSB, #15 Felt, Classic® Shingles	0.31
OSB, Fiberglas® Reinforced Felt, Classic® Shingles	0.32
OSB, Nonbreathable, Classic® Shingles	0.27

The second question examined was the impact of sample conditioning on the overall test results. Moisture within the individual components, especially a large mass element like a 24" x 36" x $\frac{7}{16}$ " OSB, could impact the overall results of a permeability test if not properly accounted for.



Figure 5: Initial System Sample



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System Testing with Equilibrium Conditioning – As a follow-up to the original testing, a full secondary set of testing was conducted on system boards that were conditioned before testing, in the controlled humidity and temperature chamber for 45 days to reach equilibrium within the components and the system layers. Care was also taken to be sure that equilibrium was reached during the weight measuring phase of the testing.

Low levels of moisture transfer resulted in a total test time of 56 days to allow sufficient moisture to be spread over time to accommodate the accuracy of the weight scale that was used.⁵ These verification tests also showed a full vapor retarder presented both with the industry standard 15-lb. felt and with the nonbreathable synthetic underlayment.

Table 3: Validation Testing of Conditioned Roofing System

TEST MATERIAL	PERMEANCE RATING
OSB, #15 Felt, Classic® Shingles	0.12
OSB, Nonbreathable, Classic® Shingles	0.15

Adding a “dummy” sample set – The “dummy” sample also gave some additional opportunities for the test method, but as well, it served to validate the initial system results. This sample set was built with a full vapor barrier, a ¼" sheet of standard Plexiglass™ thermoplastic.



Testing Summary

Each test procedure iteration, repeat testing, test component analysis and roof system check consistently reinforced the hypothesis that conventional system construction in accordance with manufacturer’s instructions creates a nonbreathable roofing system as a weather barrier for attic assemblies. In the same respect that rainwater and exterior elements are kept out of attics by the overlapping construction of the shingle system, interior moisture from within the home does not escape through the shingles. Incorporating a permeable underlayment layer into the roof system does not improve the system breathability of the roofing system.

“Interior moisture from within the home does not escape through the shingles.”

Managing Moisture in a Roof Deck or Attic

If a decking sheet or attic space contains moisture and the roofing system is a vapor retarder or a vapor barrier, how do you manage that moisture?

The key is proper ventilation or protection of the underside of the roof deck with an appropriate unvented roof assembly. With the asphalt shingle layer acting as a vapor retarder, moisture should be vented to the building exterior through the space below or otherwise managed. With conventional, vented attics, this reinforces the best practice of ventilation both at the eave or soffit, and the ridge of steep-slope roof constructions. Most building codes require a ratio of one to 300 (1:300) for net free vent area to square foot of attic space. Emerging practices in attic design using “unvented attic space” must also account for the layered vapor barrier of asphalt shingles by introducing drainage and vapor planes below the shingles and above the unvented space.

Proper venting—and, in turn, proper air flow beneath the asphalt shingles and underlayment layers—will keep a roof deck and attic space dry and functioning as designed throughout the life of the roofing system, with or without a breathable underlayment below the shingles.

⁵ ASTM E 96 Sect. 6.3 Balance & Weights.





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Joseph Lstiburek is a principal of Building Science Corporation and is one of the world's foremost authorities on energy-efficient construction techniques.

He has conducted forensic investigations and served as an expert witness on building failures all over the United States. Dr. Lstiburek is internationally recognized as an expert in the areas of rain penetration, air barriers, vapor barriers, air quality, durability and construction technology.

Dr. Lstiburek has written numerous books and technical papers on building construction, indoor air quality and durability and is an acclaimed public speaker and lecturer in building science. He attended the University of Toronto, where he earned an undergraduate degree in mechanical engineering, a master's degree in civil engineering and a doctorate in building science.

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Dr. Karagiozis is one of the leading building scientists in North America, with more than 20 years of building science research experience. As the director of building science at Owens Corning, he is responsible for leading, shaping, driving, educating and training others in energy efficiency and green building science at Owens Corning. His activities involve feeding Owens Corning's innovation pipeline with customer-inspired and building science-informed solutions.

As an expert in the area of moisture engineering, he has solved many hygrothermal design and retrofit challenges, and has developed multiple design guidelines for various envelope systems. He has also developed some of the world's most advanced hygrothermal models worldwide (WUFI, MOISTUREEXPERT, LATENITE family).

Dr. Karagiozis is the author of more than 120 technical papers and reports related to moisture in buildings.

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Paul Gassman is a product and process engineer with Owens Corning Roofing and Asphalt, LLC, with 18 years of experience in design, development and manufacturing of building materials products. He holds a Bachelor of Science in civil engineering from the Ohio State University and has been a registered professional engineer in the state of Ohio since 1990.



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