Building Science Bulletin

Understanding High Perm vs. Low Perm

High perm(eability) vs. low perm(eability) within the housewrap category...what does it mean and how does it affect your building practices? The intent of this paper is to explain this property thoroughly so that a better understanding of this building science principle can be gained.

The first step in understanding high perm vs. low perm housewraps is to break down the physical attributes of what a high quality housewrap can offer. A good weather resistive barrier (WRB) housewrap has 4 equally important functions:

1. It MUST have a high level of air resistance – to help prevent drafts, reduce energy bills and resist the flow of moisture laden air though wall cavities.
2. It MUST have a high level of water resistance – to help protect the wall cavity from water that gets behind the cladding.
3. It MUST have moderate to high vapor permeability – to promote drying in wall systems.
4. It MUST be durable -to withstand the rigors of the construction site and continue to perform once construction is completed.

While all 4 properties are important, it is **permeability** that is probably the most ignored and the least understood function, yet it can have the greatest impact on how a wall system performs. So let's take a look at this critical property.

What is Vapor Permeability?

Vapor permeability (commonly referred to as breathability) is a material's ability to allow water "vapor" to pass. This is often confused with the concept of holding out bulk water. So what's the difference? Bulk water is moisture in liquid form; water vapor is a gas. Also, the amount of moisture that moves and the method of movement are significantly different. A single drop of water consists of thousands of molecules. In general this can be compared to a crowd of people who do everything together. This is the way they like to travel. Now just imagine this crowd of people trying to go through a door all at the same time. They won't fit so no one gets through. But just suppose everyone in the crowd spreads out, and in an orderly fashion and one-by-one, they attempted to exit. Some of them would get out.

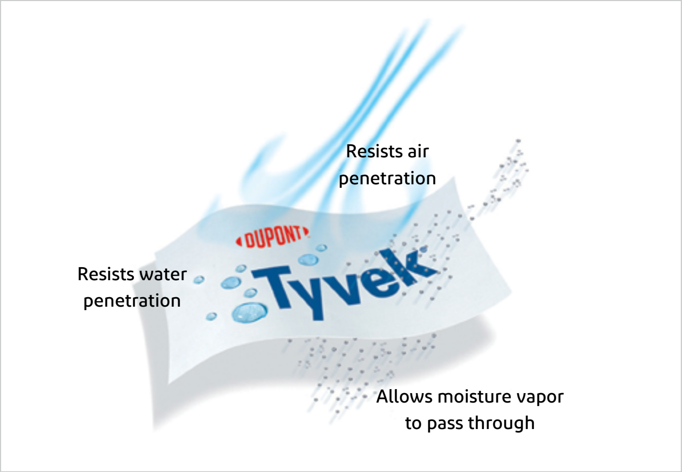

Figure A

In just the same way, when thousands of molecules of water get behind cladding, they can't fit through the small pores in the housewrap. When you have moisture vapor in your wall, one molecule can break away from the pack and is able to escape by diffusion. When a material allows these individual molecules to pass we call it vapor permeable. Building codes require that WRB's be vapor permeable and establish the minimum allowable level to be around 5 perms. This value is based on traditional building practices and does not necessarily address the requirements of modern energy efficient construction, new cladding systems and materials. DuPont Building Scientists believe that 5 perms are not enough to ensure the kind of consistent performance you need from a WRB. DuPont suggests that a WRB have a moderate to high vapor permeability.

So why is vapor permeability important? Because wall cavities do get wet, roofs leak, condensation occurs, plumbing leaks, construction materials are installed wet and internal moisture loads can be very high. However it happens, walls get wet and require a way to dry out. When a wall can't dry out, it becomes vulnerable to moisture-induced damage including mold and rot. DuPont Building Scientists believe in designing and building forgiving wall systems. All WRBs produced by DuPont, are engineered to allow maximum drying while still maintaining the other critical properties.

DuPont™ Tyvek® is very different from every housewrap on the market!

DuPont™ Tyvek® weather resistive barriers help provide the right type of protection you need and require for your wall systems.

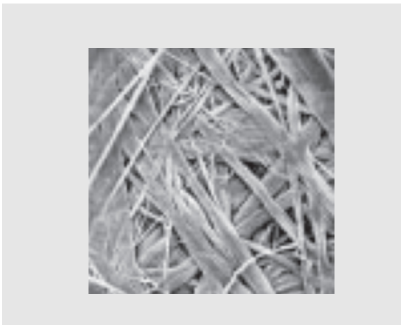

Figure B – DuPont™ Tyvek® fibers (magnified 75x) form a strong web that maintains excellent breathability and water holdout.

What is DuPont™ Tyvek®?

DuPont™ Tyvek® (Figure B) is a continuous non-woven, non-perforated sheet made by spinning extremely fine continuous high-density polyethylene (HDPE) fibers that are fused together to form a strong uniform web. (Imagine thousands of spider webs being laid down to form one large sheet.) This tough and unique structure is not susceptible to property losses inflicted by stresses in any direction. The fibrous structure is engineered to create millions of extremely small pores that resist bulk water and air penetration while allowing water vapor to pass through. No thin fragile films or punched holes are needed with DuPont™ Tyvek® to permit water vapor permeability. This is the uniqueness of Tyvek® – a true miracle of science.

How Do You Measure Permeability?

There are two standard laboratory measurement tests, which are described below. Standard lab tests are good measuring tools, but what happens in a "real world" environment? Since DuPont is a world leader in scientific Research and Design, we have also included a description and the results of a "real world" field evaluation.

The Laboratory Test – ASTM E96

Moisture vapor transmission rate (MVTR) is the measurement referenced in building codes. This is measured in a lab using ASTM E96. The test method measures how much moisture vapor is allowed to pass in a 24-hour period. This measurement can be impacted by vapor pressure, so when you want to compare materials you adjust the measurement for vapor pressure across the sample to get the moisture vapor permeance (MVP). The unit of measurement for MVP is perms. We can use ASTM E96 to give materials a relative rating to show how resistant a material is to allowing moisture vapor to pass. The higher the number, the more moisture vapor the material will allow to pass, and the better drying the material allows. For comparison, the following chart (figure C) shows the relative vapor permeance of several weather resistive membranes.

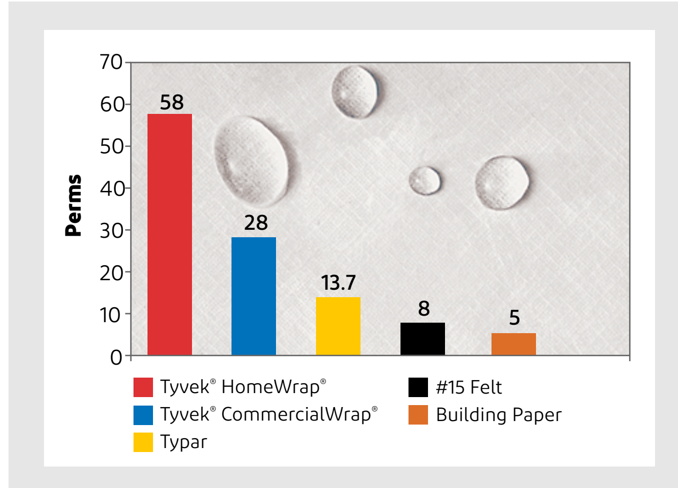

Figure C – MVTR of Weather Resistive Barriers

Note: MVTR based on published data for DuPont™, Tyvek® and Typar®; laboratory testing for felt and typical for building paper.

The above data can be used to compare a material's moisture vapor transmission property but does not necessarily indicate how that relates to a wall system's performance in the "real world." Because of this, Dupont Building Scientists perform a series of R & D tests from standard tests to practical evaluations to field studies to modeling and then we are able to publish well-rounded and fact-based suggestions for the building industry.

The Practical Test-OSB Drying Test

To develop a practical understanding of the relative impact of moisture vapor permeability on drying, a simple drying test was developed to compare a range of moisture vapor permeabilities to their impact on the natural drying potential of a material. To conduct this evaluation, several pieces of oriented strand board (OSB) were saturated in water. Each piece was placed in a sealed pouch constructed of commercially available WRBs and hung to dry. Along with the samples was a piece of OSB in an open mesh bag to simulate the natural drying rate of the OSB. The weight of each bag was measured at intervals to determine the change in moisture content of the OSB. The pouches were placed in different temperature & humidity controlled environments to simulate variable climate conditions. The test covered North America's diverse climate ranges, which included, Hot Dry, Hot Humid, Cool Wet and Cool Dry. (Please refer to Figure D and E for test results)

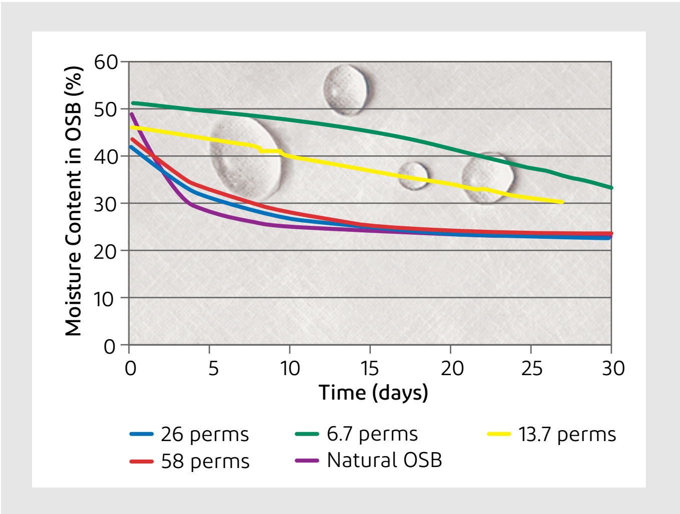

Figure D – OSB Drying Curves (100°F/90%RH)

** All testing was performed on commercially available weather resistive barriers.

These graphs show the moisture content of the OSB vs. time. As you can see, the drying curve of the moderate to high perm products closely resembles the drying curve of the natural OSB.

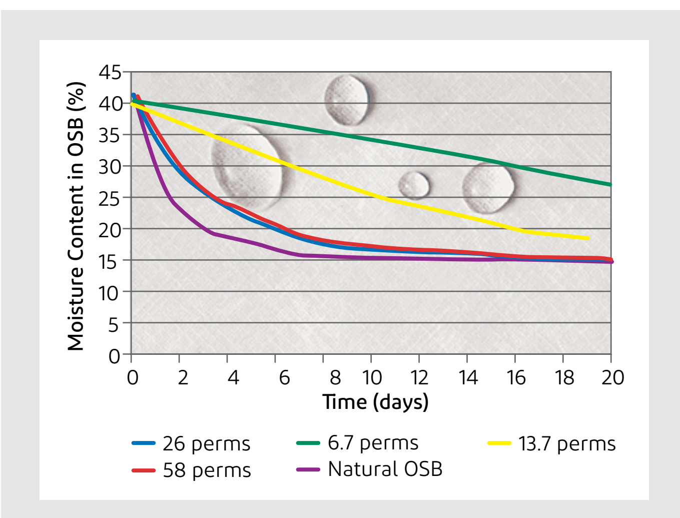

Figure E – OSB Drying Curves (85°F/80%RH)

The results are clear. In each test condition, the drying rate of the OSB inside the moderate to high vapor permeable WRBs, are close to that of the uncovered OSB. On the other hand, the test indicates that a WRB with lower vapor permeability, can have an adverse impact on the natural drying capacity of the OSB. If drying is negatively impacted, moisture issues are – more likely to occur, increasing the potential for mold, mildew and rot.

The graphs show the moisture content of the OSB vs. time. As you can see the drying curve of the moderate to high perm products closely resembles the drying curve of the natural OSB.

Field evaluations – not just in a lab, but in the real world

The OSB drying data supports the numerous field observations that we have made throughout the country and across different climate zones. Consistently, buildings with trapped moisture were associated with low perm materials. The following is a "real world" example of DuPont Building Science R&D in permeability. This incident happened in the summer of 2002.

Field Investigation

In North Carolina, during the worst drought in decades, a high permeability WRB (58 perms) and a low permeability WRB (6.7 perms) were randomly applied by a builder on the same wall structure. The structure was wrapped for 3–4 weeks and was left in the framed stage of construction (the roof and roofing underlayment in place, windows installed and the interior wall cavity open) during this time period. At the end of 3–4 weeks, it was apparent that moisture accumulation and elevated moisture levels had occurred everywhere the low permeability (6.7 perm) WRB was installed. Many of these areas had reached or exceeded the saturation levels for the sheathing, and moisture distress was evident, even to the naked eye. In contrast, everywhere the high permeable (58 perm) WRB was installed, the sheathing membrane was clean and dry. The conditions noted were consistent, regardless of location on the building and directional orientation.

Figure F – Low vapor permeable housewrap with high moisture reading on OSB under housewrap

Figure G – High vapor permeable housewrap with low moisture reading on OSB under the DuPont™ Tyvek® HomeWrap®

Figure H – Figures F, G & H depict typical findings on the North Carolina wall system during the summer 2002 field investigation. A moisture meter was used to measure the moisture content. Figure F shows the high moisture content behind the low vapor permeability housewrap (moisture meter reading was 27.6). Figure G shows the low moisture content behind the high vapor permeability housewrap (DuPont™ Tyvek®) in an area that was directly below figure F (moisture meter reading was 12.1 – less than half of the reading directly above it.) Figure H shows the condition of the OSB directly behind this transition area.

The moisture source for this structure was determined to be condensation (dew). Dew is a naturally occurring phenomenon. Its appearance is no surprise to anyone. The low perm WRB did not allow this small amount of moisture to escape, and over a very short period of time, resulted in significant moisture accumulation and distress. Bottom line- the low perm WRB would not allow the building to dry. Regardless of the source of the moisture, a WRB must allow the wall to dry out. Wood components exposed to high levels of moisture for extended periods are at risk for mold, mildew and rot. Mold thrives in the presence of four conditions: spores, food source, temperature and moisture. The ONLY condition a builder can control is moisture. Building walls that are capable of drying is an important part of the overall moisture management system and an important building practice to follow to help safeguard against potential mold litigation.

North Carolina isn't the only location where these conditions have been observed. Similar conditions have been observed in Connecticut, Ohio, Virginia and Illinois. Drying is a critical component of moisture management which can be impacted by climate. The material properties, practical tests and field observations support our conclusion and position that low permeability WRBs are not good for a wall system regardless of where you choose to build. It just plain makes sense, the faster a wall is allowed to dry, the more durable and problem-free a wall system will be.

Moisture modeling – not just in the field -but in the virtual world

The lab results and field observations led us to do moisture modeling to better understand what we have observed. We chose the WUFI Pro model which is recognized internationally by building scientists as an effective moisture modeling program. DuPont was able to simulate the field cases observed, taking into account location, weather data and construction type. The model was used to simulate field conditions and evaluate the wall system's response to the formation of dew-like condensate. The results showed that in all climates, the OSB maintained a significantly lower moisture content when a moderate to high vapor permeable housewrap was used. In some cases, the difference in OSB moisture content was as much as 2X, confirming the observations in the field and in the lab.

So in the lab, in the field and in the virtual world of modeling we have observed that moderate to high permeability allows drying while low permeability impedes drying, increasing the potential for moisture-related issues.

All builders' goals are to build quality homes that last. The idea is to build a durable structure with wall systems that resist water and air while maintaining breathability. There is only one weather resistant barrier that meets all of these critical performance criteria, DuPont™ Tyvek®. It is engineered to help provide the optimum balance of properties for superior performance including a moderate to high vapor permeability, which will allow walls to dry faster when properly constructed.

Balance of Performance:	Tyvek® HomeWrap®	Perforated Wraps	Low Perm Microporous Film Wraps	Grade D Building Paper	#15 Felt
Air Penetration Resistance air-ins test [cfm/ft²@ 75 PA]	HIGHEST air penetration protection **[.004]**	Mechanical pinholes allow air penetration **[.1 – .9]**	Film abrasion can cause holes that reduce protection	Minimal air penetration resistance, not designed as an air barrier	Minimal air penetration resistance, not designed as an air barrier
Bulk Water Holdout (AATCC-127) hydrostatic head [cm]	HIGHEST water holdout **[210]**	Mechanical holes allow water penetration **[10 – 25]**	Reduced water holdout **[165 – 180]**	Absorbs water	Absorbs water **[52]**
Moisture Vapor Permeance (ASTM E96) vapor transmission [perms]	HIGH breathability, lets moisture escape **[58]**	Holes allow moisture to get out **[6 – 18]**	Low vapor permeability **[6.7 – 13.7]**	10x less permeable than Tyvek® **[5]**	7x less permeable than Tyvek® **[8]**
Durability	EXCELLENT tear strength, good wet strength	Streching, fatigue & aging may reduce performance	Film suseptible to abrasion during installation	Tears and punctures easily, loss of strength when wet	2x less tear strength than Tyvek®

DUPONT

Tyvek®

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