BKU Product Knowledge Study Guide

Attributes of Tyvek®: Air Barrier

4 Key Attributes of DuPont™ Tyvek® Building Wraps

Throughout the product knowledge modules, we will be focusing on 4 key attributes of housewraps.

1. Durability
2. Vapor Permeable
3. Water Barrier
4. **Air Barrier**

DuPont™ Tyvek® building wraps are durable, vapor permeable and function as water barriers and air barriers when installed correctly. This module will focus specifically on air barriers.

Critical Performance Requirements for Air Barriers:

When discussing air barrier's there are different critical performance requirements which include:

1. Air Infiltration Resistance
2. Continuity
3. Structural Integrity
4. Durability

What is an Air Barrier System?

An air barrier system is the complete air control layer system comprised of materials and assemblies, each with their own performance requirements. DuPont™ Tyvek® started off as strictly an air barrier, and then in the 1990's, DuPont™ Tyvek® received code acceptance as a weather-resistive barrier. Air barriers are unique in that they can resist both air flow and air pressure. They help to separate conditioned and unconditioned air.

Why is Air Resistance So Important?

Studies of heat loss in buildings demonstrate that:

- Regardless of insulation type, a wall's thermal performance drops proportionately as air flow through the wall increases.
- Sheathings alone do not reduce airflow enough to improve thermal performance of walls.
- Air flow can increase the heat load, even if the air flow does not fully penetrate to the home's interior.

If properly installed, Tyvek WRBs have the air barrier properties to help drastically reduce air leakage. Stopping air leaks significantly helps to reduce moisture penetration in the walls, as well as increase energy savings, and also increases the overall comfort in a home.

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Housewrap Energy/Greenhouse Hass Payback

The following table shows the Energy and GHG Payback from using a housewrap. The savings presented in the table are based on the % Air Change per House (ACH) Reduction and assumption of average house ACH and energy usage.

	Million BTU	GHG (CO_2 equivalents in pounds)
Housewrap Embodied Energy	1.21 to 1.77	70 to 98
Annual Energy Savings * low estimate (based on 10% ACH Reduction)	12	1,630
Annual Energy Savings * high estimate (based on 50% ACH Reduction)	60.2	8,140
Energy Payback	**7 to 54 days**	**3 to 22**

What is Air Leakage?

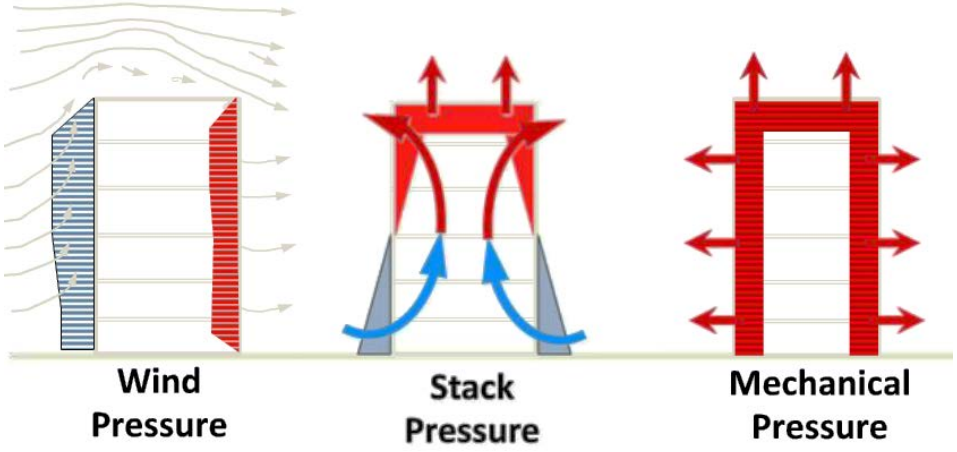
Air leakage is the **un**-planned, **un**-predictable and **un**-intentional air flow through the building envelope, and it is not to be confused with the intentional air intake or exhaust for planned ventilation. Air leakage needs 2 things in order to happen:

1. **A driving force** - which is the air pressure difference across the envelope
2. **A pathway -** any holes or discontinuities in the building envelope, or porous/leaky materials

Since most air pressure sources cannot be eliminated, the air leakage is controlled by sealing the building envelope– e.g. a continuous Air Control Layer or Air Barrier.

Sources of Air Pressure Difference (ΔP)

The 3 main sources of air pressure include:



Air Leakage Impact on Buildings

Air leakage impacts several aspects of building performance including: **Moisture management**, **Indoor Air Quality** (IAQ) and **Thermal Comfort**, and **HVAC Energy** use. Reducing air leakage can result in up to **35% heating energy cost savings** in certain climates (National Institute of Standards).

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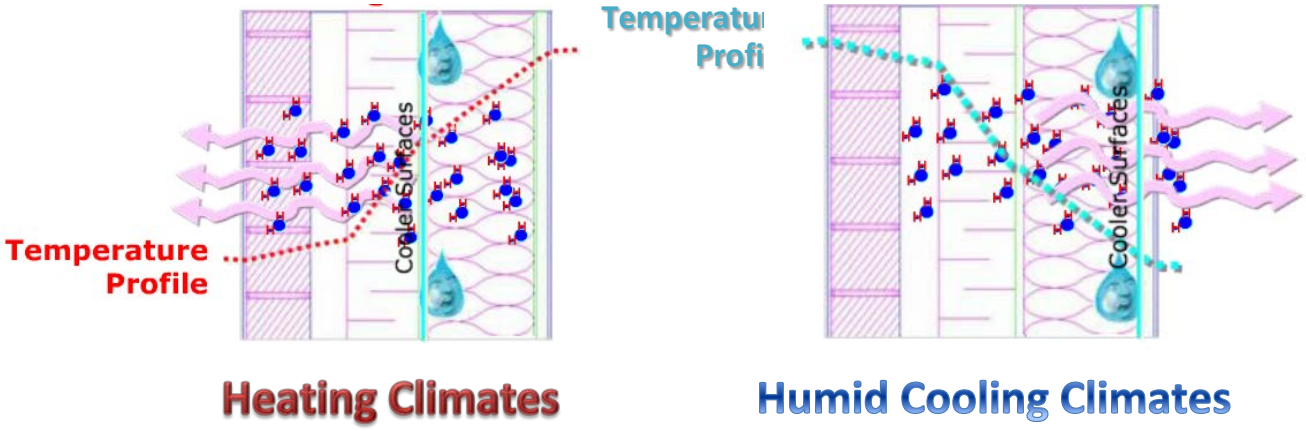
Air Transported Moisture

Air transported moisture can lead to interstitial condensation (condensation on the interior surfaces of the building envelope). In heating climates, the focus is on interior moisture-laiden air exfiltration. This chart shows schematically how **air exfiltration in heating climates** could lead to condensation on cooler exterior surfaces. In **humid cooling climates**, the concern is reversed and focuses on exterior moisture-laiden air **infiltration** into air-conditioned, cooler structures.

The warmer outside air can hold a higher amount of moisture, hence air infiltration can deposit excess moisture on cooler interior surfaces (e.g. the back-side of the vapor barrier) leading to condensation. In both cases, repeated condensation coupled with slow drying rates (e.g. vapor retarder/vapor barriers) could lead to moisture problems.



Transported Moisture must not be confused with Vapor Diffusion. In Air Transport Moisture the air carrying the water moves in a “free ride” pattern while water vapor diffusion is a slow molecular movement. 98% of all of the water vapor migrates in air transported moisture while about only 2% of all water vapor migrates during water vapor diffusion.

Acceptance Criteria for Air Barriers

The acceptance criterion for air barriers is the minimum number that a product must test above to qualify as an air barrier. There are several test methods for air penetration resistance which fall into three categories: Air Barrier Materials, Air Barrier Assembly and Whole Building. Each one of the test methods for air penetration resistance comes with its own standard requirements that need to be met and a series of codes that go along with these requirements.

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Air Barrier Testing

Here is a summary Chart of the multiple ways of testing for air barriers that will be discussed in this module.

Method	Sample Type	Sample Size	Units	Performance Specifications @1.57 psf/@75Pa	Code Reference
TAPPI-T460 (Gurley Hill)	Air Barrier Material	1" x 1"	Sec/100 ml		NA
ASTM E2178		1m x 1m	cfm/ft^2 or $L/(s*m)^2$ @ various pressure differences	≤0.004 cfm/ft^2 ≤0.02 $L/(s*m^2)$	USACE, ICC-ES AC-38, NIBS
ASTM E283	Air Barrier Assembly	Appropriate size wall assembly	cfm/ft^2 or $L/(s*m)^2$ @ various pressure differences		ASTM E1677, ABAA, NIBS
ASTM E1677		8' x 8' (standard)	cfm/ft^2 or $L/(s*m)^2$ @ various pressure differences	≤0.04 cfm/ft^2 ≤0.2 $L/(s*m^2)$	
ASTM E2357		8' x 8' (standard)	cfm/ft^2 or $L/(s*m)^2$ @ various pressure differences		Canada AIB System Technical Guide
ASTM E1424		8' x 8' (standard)	cfm/ft^2 or $L/(s*m)^2$ @ various pressure differences	≤0.06 cfm/ft^2 ≤0.3 $L/(s*m^2)$	
ASTM E779	Whole Building	Whole house	Air changes per hour (ACH)	≤0.25 cfm/ft^2	USACE Report can be combined with IR analysis

Some examples of air barrier materials used in Residential and Commercial building projects include: building wraps, fluid applied materials, and spray polyurethane; each of which is used in both residential and commercial construction. Additionally, peel and stick membranes are used in commercial construction.

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Products with ICC-ES Air Barrier Evaluation

The chart below shows all of the products that are ICC-ES Air Barriers. Note that perforated wrap materials do not meet air barrier requirements.

COMPANY	PRODUCT NAME	TYPE
JX Nippon ANCI, Inc.	Exaire® Plus Housewrap, Exaire® Plus Commercial Housewrap and Exaire® Plus Low Perm Housewrap	Wrap
Fiberweb	Typar® HouseWrap, Surround™ Housewrap B, W and G Weather-Resistant Barriers; Typar® StormWrap Weather-Resistant Barriers; Typar® HouseWrap Weather-Resistant Barriers;Typar® MetroWrap Weather Resistant Barriers; and Typar® CertaWrap Weather-Resistant Barriers	Wrap
Huber Engineered Woods, LLC	ZIP System® Wall Sheathing	OSB Wood Structural Panel
Alpha ProTech Engineered Products, Inc.	REX Wrap Plus Protective House Wrap and Rex Wrap Homewrap Water-Resistive Barriers and Air Barriers	Wrap
E.I. du Pont de Nemours and Company	DuPont™ Tyvek® ThermaWrap™, DuPont™ Tyvek® HomeWrap®, DuPont™ Tyvek® StuccoWrap®, DuPont™ Tyvek® DrainWrap™, DuPont™ Tyvek® CommercialWrap®, DuPont™ Tyvek® CommercialWrap® D weatherization barriers	Wrap
The Dow Chemical Company	Styrofoam™ Brand Insulation Boards and Dow Fan-Fold Products, FROTH-PAK™ Polyurethane Foam Insulation, WEATHERMATE Plus ™	Boards/ Foam Insulation/Wrap
Pactiv Building Products	GreenGuard® Ultra Wrap Building Wrap, GreenGuard® RainDrop Building Wrap, GreenGuard® MAX Building Wrap, GreenGuard® C500 Building Wrap and GreenGuard® C2000 Building Wrap	Wrap
Cosella-Dorken Products Inc	DELTA®-MAXX, DELTA®-MAXX PLUS, DELTA®-VENT S, DELTA®-VENT S PLUS,	

This next chart shows all of the products that are qualified as air barriers by the Canadian Construction Material Center (CCMC).

COMPANY	PRODUCT NAME	TYPE
E.I. du Pont de Nemours and Company	Tyvek® HomeWrap®, CommercialWrap® - Air Barrier Material	Wrap
FIBERWEB Inc.	TYPAR® HouseWrap CentraWrap™, Surround HouseWrap, TYPAR® MetroWrap™ TEKTON MetroWrap™ - Air Barrier Material	Wrap
Isolofoam Group Inc.	Isoclad ® - Air Barrier Matieral	Insulation Panel
Sto Corp.	Sto Guard® - Air Barrier Matieral	Spray
Pactiv Building Products	GreenGuard® MAX™ - Air Barrier Matieral	Wrap
PGI Fabrene Inc.	Air-Gard® Ultra BP AIR LOCK	Wrap
Intertape Polymer Corp.	FlexGard Aspire™, PermaGuard ™, PermaGard ™, Dri-Shield ™ II, Xmark HouseWRap, Grip-Rite® HouseWrap	Wrap
Building Products of Canada Corp	Enermax	Panel
Raven Industries Inc.	Fortress Pro – Air Barrier Material	Wrap
Jumpstart Consultants, Inc.	GuardWrap® - Air Barrier Material	Wrap

Gurley-Hill Test (TAPPI T460) – Air Barrier Material Test

The first air barrier materials test we will discuss is the Gurley-Hill Test (TAPPI T460), which measures how long it takes to push 100 cubic centimeters of air through a 1-inch diameter sample of material at a given pressure. The higher the number, the more resistant the sample is to air penetration. This is a standardized, repeatable test which has its advantages and disadvantages.

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The disadvantages are:

- With such a small sample size the test cannot adequately measure the uniformity of the air barrier substrate performance because material properties often vary from spot to spot.*

The advantages of the test are:

- The test is inexpensive
- Commonly used in the industry
- Generates quick results

*For example, when looking at perforated wrap, the results vary depending on how many perforations exist in the given sample.

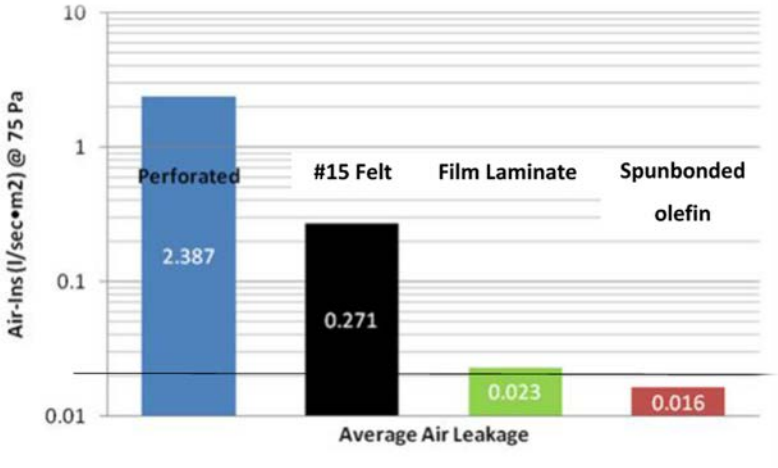
ASTM E2178 – Air Barrier Material Test

The next test under the Air Barrier Materials category is ASTM E2178, also used as part of meeting the Canadian National Building Code. This test uses a sample size of 1 square meter. This test area is large enough to get a reliable cross-section, making it a more accurate representation of the sheet structure as compared to Gurley Hill. It measures just the air infiltration barrier wrap which is a true performance measure.

Below is a table of air barrier material ASTM E2178 specifications.

Required by:	Specifications	Comments	Canadian / US
US General Services Administration (GSA)	≤ .004 cfm/ft² at .3 in. H_2O ≤ .02 L/(s·m²) at 75 Pa		US
US Army Core of Engineers (USACE)	≤ .004 cfm/ft² at .3 in. H_2O ≤ .02 L/(s·m²) at 75 Pa		US
International Residential Code (IRC)	≤ .004 cfm/ft² at .3 in. H_2O ≤ .02 L/(s·m²) at 75 Pa	In definition of "Air Impermeable Insulation" only	US
International Energy Conservation Code (IECC) Commercial Section	≤ .004 cfm/ft² at .3 in. H_2O ≤ .02 L/(s·m²) at 75 Pa	One of three compliance options	US
ASHRAE 90.1	≤ .004 cfm/ft² at .3 in. H_2O ≤ .02 L/(s·m²) at 75 Pa		
National Building Code of Canada	≤ .004 cfm/ft² at .3 in. H_2O ≤ .02 L/(s·m²) at 75 Pa		`Canada
ICC-ES AC38	≤ .004 cfm/ft² at .3 in. H_2O ≤ .02 L/(s·m²) at 75 Pa	Optional rating for water-resistive barrier	US

This graph shows how other wraps compare to Tyvek®. On the left is an average of representative perforated wraps. They have very high air permeability and do not meet and air barrier standards.



It is important to keep in mind that this is a log scale so when you compare Tyvek® products to the other products there is two to three hundred times difference in air resistance. New products are

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becoming more like Tyvek and finding ways to pass the standards.

ASTM E238 – Air Barrier Assembly Test

One example of an assembly air leakage test is ASTM E283 a standard test method for Rate of Air Leakage through exterior windows, curtain walls, and doors under specified pressure differences across the specimen. This test uses an 8 by 8 foot sample. It is referenced in ASTM E1677. The limitation of this test is that it allows manufactures to control variables that can radically affect performance of a product. Test Wall sections could be built with biases that may enhance the performance of a product being tested. Standard conditions are not established for comparing one manufacturer to another.

ASTM E-1677 – Air Barrier Assembly Test

Standard specification ASTM E1677 defines an air barrier by three measurable performance attributes: Air leakage (as tested by E283), structural integrity (as tested by E330) and water resistance (as tested by E331). ASTM E1677 also classifies air barriers as either Type 1 or Type 2.

Air Leakage and Structural Integrity both have the same standards of testing regardless of which type. On the other hand, Water Resistance testing differs between the two types. A Type I Air Barrier is tested by spraying the wall with water in a 15mph wind whereas for a Type II Air Barrier, a test for water resistance is not required. All DuPont Tyvek WRBs fall under Type I air barriers

ASTM E2357 – Air Barrier Assembly Test

ASTM E2357 is a standard test method for determining Air Leakage of Air Barrier assemblies. The sample size is 8ft by 8ft and it builds off the E283 test. It tests the entire air barrier assembly with all components installed including air barrier, flashing and sealing materials. This test uses a realistic wall mock-up, complete with typical wall penetrations. It requires 7 measurements of air leakage rate under both positive and negative pressures.

This test is carried out by securing a specimen to the test apparatus and subjecting the specimen to a specified wind-load schedule with both positive and negative loads during distinct loading stages. The difference between ASTM E1677 and ASTM E2357 is illustrated in the chart below and the procedure box in the lower right corner specifies the wind-load schedule for ASTM E2357.

	ASTM E1677-05	ASTM E2357-05
Number of Test Specimen and configuration	One Specimen: Opaque Wall (8 x 8-ft walls) (fasteners to simulate wood siding or brick ties required)	Test two of the three Specimens (8 x 8 -ft walls): 1 – Opaque Wall 2 – Wall with penetrations 3 – Wall-Foundation Interface
Conditions for Air Leakage Testing	**Five Test Pressures:** • 75Pa (1.56 psf, 25 mph) • two pressures below 75 Pa • two pressures above 75 Pa Air leakage results are reported at 75Pa ***(Positive & negative pressures)***	**Seven Test Pressures:** +/- 25Pa (0.56 psf, 15 mph) +/- 50Pa (1.04 psf, 20 mph) +/- 75Pa (1.56 psf, 25 mph) +/- 100Pa (2.09 psf, 30 mph) +/- 150Pa (3.24 psf, 35 mph) +/- 250Pa (5.23 psf, 45 mph) +/- 300Pa (6.24 psf, 50 mph) ***(Positive & negative pressures)***
Pressure Loading Schedule	Sustained loads up to +/- 500 Pa (10.4 psf, 65 mph) ***(Positive & negative pressures)***	1 - Sustained, +/- 600Pa (12.5 psf, 71 mph) 2 - Cyclic, +/- 800 Pa (16.7 psf, 82 mph) 3 - Gust, +/- 1200 (25 psf, 100 mph) ***(Positive & negative pressures)***

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The first difference is in the number or test specimens that are required for each test. ASTM E1677 only has one specimen while ASTM E2357 requires two specimens. Next, we look at the conditions for air leakage testing. ASTM E1677 has five test pressures as seen in the chart whereas ASTM2357 tests seven different pressures. Finally when looking at the pressure loading schedule it can be seen that each test has its own unique standards.

ASTM E1424 – Air Barrier Assembly Test

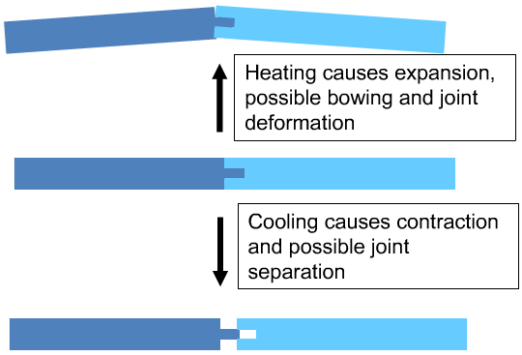
ASTM E1424 is a standard test method for determining the rate of air leakage through exterior windows, curtain walls and doors under specified pressure and temperature differences across the specimen. This test adds dimension by allowing for a variance in temperature across a test wall. This simulates environmental factors such as heat, cold, wind, etc. This test is fairly expensive to run and is not used very often.

Air Barrier Assembly Case Study

A laboratory investigation found that when exposed to a 9 mph wind, DuPont™ Tyvek® HomeWrap® helped to retain 94% of the designed R-value in a wall system, as opposed to only 37% without it. A wall would lose about 66% of the designed R-value in a wall system by not using Tyvek®.

Foam Sheathing Air Barriers

The ASTM Standard D-2126: Standard Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging allows 2% expansion or contraction before they are deemed dimensionally unstable. This allowed expansion and contraction can lead to either "gapping" or "bowing" at seams.

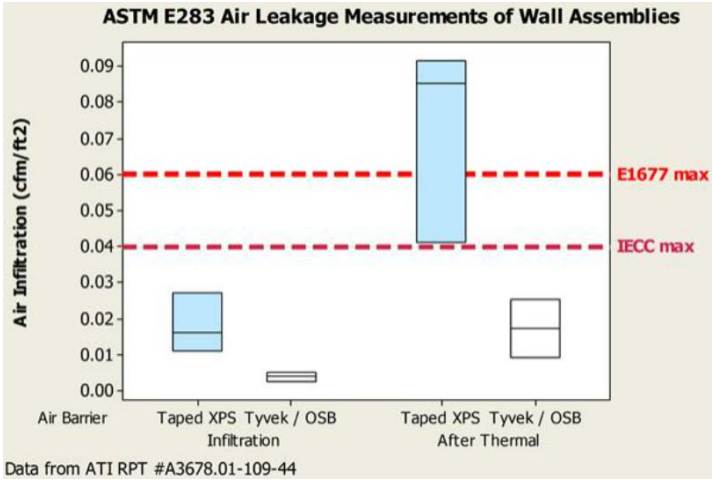


The graphic shows foam sheathing which was subjected to thermal cycling – the two boards started flat and the distortion was due to board thermal instability. Through heating and expansion, the sheathing will buckle. Conversely through cooling and contraction the sheathing will shrink and separate.

This thermal instability leads to failure in taped joints. The failure of taped joints not only affects the water-resistance of the wall assembly, but also affects the air leakage performance of the wall. Remember that air leakage control is critical to energy efficiency.

"Taped rigid insulation is not allowed as an air barrier in Wisconsin. When some types of insulation boards get colder by 70°F, they can shrink ¼" on all sides. The tape cannot adequately perform under such circumstances." – *Air Barrier Update, International Masonry Institute Technology Brief, January 2004.*

These are air leakage results of laboratory assembly testing before and after thermal cycling. The results show that that taped Tyvek® wrap over OSB is tighter and less variable than taped XPS. Thermal cycling increases the air leakage and variability of both systems, but where the Tyvek® system continues to meet code requirements the taped foam system does not.



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Air Barrier Testing

The last of the three categories of Air Penetration Tests is the Whole Building Test.

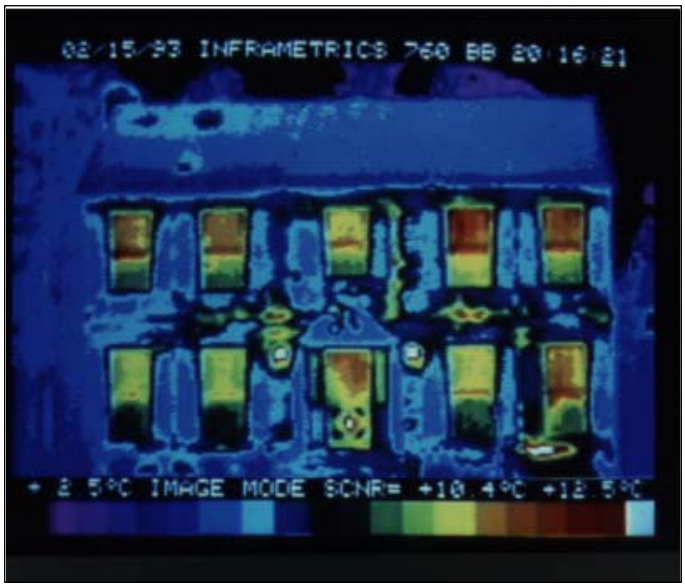
ASTM E779 – Whole Building Test

An example of a Whole Building Test is ASTM E779, also called the Blower Door Test. The Blower Door Test is a standard test method for determining Air leakage rate by fan pressurization. The Bower Test works by first either pressurizing or depressurizing a home and then you measure air changes per hour.

The majority of the times, buildings are pressurized. These measurements of air leakage at different pressures then help determine the relationship between change in pressure and airflow.

Case Studies – Effects of Tyvek®

To demonstrate the impact that Tyvek® has on air infiltration standpoint, two studies were conducted – one in Charlottesville, Virginia. The test examined eight production-built houses with Tyvek on them, and eight without. All the houses were covered with vinyl siding over OSB and built over crawlspaces. The effects of infiltration in these houses were demonstrated using infrared imaging, as shown in the photo below.



Air leakage (light-colored areas in the wall at exterior light fixtures near windows and at the band joist between the first and second floors) can be visually demonstrated using infrared photography. This image was captured in Charlottesville in February with outside temperatures in the mid 20's and interior temperatures at 80 degrees F.

Blower door tests were conducted on each house to understand the effects that Tyvek had on air infiltration. DuPont researchers saw a 28% drop in air infiltration just by using Tyvek®.

In another test conducted in California, the houses were built to much tighter standards to begin with – on slabs and clad in stucco over two layers of building paper. Testing found a 13% drop in air infiltration when Tyvek® StuccoWrap® was used in place of the two layers of building paper. Based on these results, builders were awarded energy credits of a half point towards compliance with state energy-efficiency standards.

USACE Required Air Barriers

US Army Corps of Engineers (USACE) has introduced the first enforceable air barrier standard in NA, which requires not only the use of air barrier materials but also testing of whole building which must meet the established airtightness level. All new buildings must: achieve an air leakage rate not to exceed 0.25 cfm/ft2 at 75Pa AND pass an air leakage test per ASTM E779.

To date, hundreds of buildings have been tested under the USACE Program and they routinely meet the airtightness standard. As a result of significant improvements in practical implementation of a continuous air barrier and in achieving whole building airtightness, USACE is now considering a further reduction in air leakage rate (0.15cfm/ft2 at 75Pa). A few examples of successful implementation of a continuous air barrier and airtight building envelope will be discussed next. USACE often built multiple buildings with the same footprint, which allowed reproducibility of practices and test results.

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Case Studies

In a test performed in Ft. Sam Houston, San Antonio, TX. two dormitories were built and tested at different times. The primary air barrier was a Tyvek® building wrap. The blower door tests on both buildings were performed by Pie Forensic Consultants.

The tests have been performed both under pressurization and depressurization and the average leakage rates for the 2 buildings were almost identical, even though construction and testing were done at different times. Both buildings not only passed the USACE requirement, but were 72% better than the USACE max allowable rate of 0.25 cfm/ft^2 @ 75Pa.

Air Barrier Association of America (ABAA) Evaluation Process

Who is ABAA?

ABAA is a trade organization representing the center of excellence in the air barrier industry. ABAA's mission is to promote the use and benefits of air barrier systems and to develop a professional specialty trade and industry dedicated to the installation of effective air barrier systems in buildings. To this end, ABAA recently initiated an air barrier evaluation process in order to confirm performance of existing air barriers versus current air barrier performance standards.

What is the ABAA Evaluation Process?

In order to ensure best practices for installation of effective air barrier systems in buildings, ABAA has requested air barrier manufacturers to complete an evaluation process in order to be registered at the ABAA web site. The evaluation process requires that manufacturers submit 3rd party reports for testing of air barrier materials and assemblies. In order for an air barrier to use the "ABAA Evaluated" logo, the manufacturer must complete the evaluation process for both air barrier materials and air barrier assemblies.

Required Documentation

ABAA evaluation process requires that manufacturers submit a comprehensive list of documentation for their air barriers, which include: (1) an application for each Air Barrier Material and Assembly they wish to list at ABAA website, (2) a list of materials and components for each assembly, (3) test results, per ABAA protocol, (4) test results from an accredited laboratory, (5) specification for the air barrier assembly, (6) detailed installation instructions, (7) approved details for the assembly, etc.

ABAA evaluations of wall air barrier assemblies using DuPont™ Tyvek® CommercialWrap®, DuPont™ Tyvek® CommercialWrap® D, DuPont™ Tyvek® Fluid Applied WB and DuPont™ weatherization components confirm that these assemblies have air leakage rates significantly below the maximum allowable when tested in accordance with ASTM E2357, exceeding ABAA assembly air leakage requirements. DuPont is now the only manufacturer to offer both mechanically fastened wrap and fluid applied products that have been confirmed to meet ABAA requirements for commercial air barrier assemblies.

Can DuPont™ Tyvek® WRBs be Installed Under Sheathing?

The question has come up for certain situations, so it should be noted that DuPont™ Tyvek® WRBs can be used either over or under sheathing. While specific code requirements may not be met, DuPont™ Tyvek® WRBs can be used under sheathing but would have the potential to function only as an air barrier and will not protect the sheathing as a secondary water barrier.

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Canada Approved Tyvek® Wraps

The US version of DuPont™ Tyvek® CommercialWrap® satisfies Canada's CCMC requirements and is approved for use in Canada. However, DuPont offers a Canadian version of DuPont™ Tyvek® HomeWrap® and DuPont™ DrainWrap™ which is different than the US version. The US version of DuPont™ Tyvek® HomeWrap® and DuPont™ DrainWrap™ does not have the CCMC designation because it does not satisfy all the Canadian requirements. For this reason, the US version of these products should not be used in Canada. For more information about differences between the US and Canadian version of these products, please refer to the applicable technical data sheet.

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