

ENVIRONMENTAL PRODUCT DECLARATION

TYVEK® FLUID APPLIED WEATHER BARRIER SYSTEMS



DuPont™ Tyvek® Fluid Applied Weather Barrier (WB) Systems offers outstanding protection for concrete, CMU, and many common sheathing substrates.



DuPont Protection Solutions is a strategic business unit of DuPont, bringing dynamic science to the discovery and development of innovative products and services for commercial and residential construction. DuPont Protection Solutions is committed to increasing the performance of building systems and creating energy efficient and durable structures. DuPont is the only manufacturer to offer both fluid applied and mechanically fastened building wrap air and water barrier systems. DuPont™ Tyvek® commercial air and water barrier systems help effectively seal the building envelope. When you choose DuPont products for your next project, you get products that meet the highest performance standards and are backed by industry-leading building science and unrivaled industry support provided by the DuPont™ Tyvek® Specialists Network and the DuPont™ Building Knowledge Center.



ENVIRONMENTAL PRODUCT DECLARATION






TYVEK® FLUID APPLIED WEATHER BARRIER SYSTEMS
AIR BARRIER FOR COMMERCIAL CONSTRUCTION

According to ISO 14025

This declaration is an environmental product declaration (EPD) in accordance with ISO 14025. EPDs rely on Life Cycle Assessment (LCA) to provide information on a number of environmental impacts of products over their life cycle. Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc. Accuracy of Results: EPDs regularly rely on estimations of impacts, and the level of accuracy in estimation of effect differs for any particular product line and reported impact. Comparability: EPDs are not comparative assertions and are either not comparable or have limited comparability when they cover different life cycle stages, are based on different product category rules or are missing relevant environmental impacts. EPDs from different programs may not be comparable.



PROGRAM OPERATOR	UL Environment
DECLARATION HOLDER	DuPont
DECLARATION NUMBER	4787059050.101.1
DECLARED PRODUCT	Tyvek® Fluid Applied Weather Barrier Systems
REFERENCE PCR	IBU Part B: Plastic and elastomer roofing and sealing sheet systems. With UL part A and part B addendum
DATE OF ISSUE	June 21, 2017
PERIOD OF VALIDITY	5 Years
CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications
The PCR review was conducted by:	Institut und Umwelt e.V.
	Independent Expert Committee
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This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories <input type="checkbox"/> INTERNAL <input checked="" type="checkbox"/> EXTERNAL	 Wade Stout, UL Environment
	 Thomas P. Gloria, Industrial Ecology Consultants
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	 Thomas P. Gloria, Industrial Ecology Consultants



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Product

Product Description

DuPont™ Tyvek® Fluid Applied Weather Barrier (WB) Systems provide building envelope protection against water penetration and air infiltration. Tyvek® Fluid Applied air and water barriers are designed for the unique demands of heavy commercial construction projects.

This innovative system of fluid applied products applies DuPont's expertise in building and material science to deliver what commercial projects require, including:

- Sustainable Building Design and Construction
- Superior Protection
- Energy Efficiency
- Ease of Installation
- Enhanced Durability
- Integrated Solutions
- Expert Support

The Tyvek® Fluid Applied WB System provides an ideal combination of air infiltration and bulk water penetration resistance with vapor permeability that allows incidental moisture to escape so that the building envelope can dry out. All products within it are low-VOC, for reduced environmental impact, and fully compatible with DuPont™ Tyvek® self-adhered flashing products.

Products in the system include:

- DuPont™ Tyvek® Fluid Applied WB and WB+ Membranes
- DuPont™ Tyvek® Fluid Applied Flashing & Joint (F&J) Compound
- DuPont™ Sealant for Tyvek® Fluid Applied System
- DuPont™ Tyvek® Fluid Applied Flashing – Brush Formulation

Application

Tyvek® Fluid Applied WB Systems are typically installed in commercial buildings where building geometry or the application substrate precludes use of mechanically fastened barrier products.

Technical Data

Product properties for the Tyvek® Fluid Applied WB are shown in Table 1. Additional information is available from DuPont's [technical data sheet](#) for the Fluid Applied WB.





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Table 1: Fluid applied product properties

Property	Value	Unit
Air Penetration Resistance - Material (ASTM E2178)	0.0002	cfm/ft. ² @ 75 Pa
Wall Assembly Air Penetration Resistance (ASTM E2357)	< 0.01	cfm/ft. ² @ 75 Pa
Wall Assembly Air Penetration Resistance (ASTM E283)	< 0.01	cfm/ft. ² @ 75 Pa
Water Penetration Resistance (ATTCC127)	> 1000	cm
Wall Assembly Water Penetration Resistance (ASTM E331)	No leakage	Tested to 15 psf
Water Vapor Transmission (ASTM E96, Method B)	25	Perms
Low Temperature Crack Bridging (ASTM 1305)	PASS	No cracking
Adhesion Strength – Concrete (ASTM D4541)	> 33	psi
Adhesion Strength - Exterior Gypsum (ASTM D4541) (delaminates fiberglass topsheet)	> 25	psi
Peel Strength (ASTM D903)	13.3 Cohesive failure	lb./in (aluminum)
Adhesion-In-Peel (ASTM C794)	PASS	lb./in (mortar)
Tensile (ASTM D412)	169	psi
Elasticity (ASTM D412)	400	%
Recovery at 300% elongation (ASTM D412)	99	%
Hardness (ASTM D2240)	71	Shore A
Ultraviolet Light Exposure (UV) – Accelerating Weathering (G155)	9	months
Nail Sealability (ASTM 1970)	PASS	No leakage
Flame Propagation. Multiple Assemblies (NFPA 285)	PASS	--
Surface Burning Characteristics (ASTM E84)	Class A	Class
	25 25	Flame Spread Index Smoke Developed Index
VOC (ASTM C1250)	<2	% (by wt.)
	25-30	g/L

Placing on the Market / Application Rules

The products considered in this EPD conform to the following technical specifications for Air and Water Resistive Barriers (WRB)

- Air Barriers: ASTM E2178-2008 (Standard Test Method for Air Permeance of Building Materials); ASTM E2357-2011 (Standard Test Method for Determining Air Leakage of Air Barrier Assemblies); ASTM E1677-2011, Standard Specification for Air Barrier (AB) Material or System for Low-Rise Framed Building Walls
- Water Resistive Barriers: ASTM E331 (Wall Assembly Water Penetration Resistance); ASTM E96-2000/E96M-2005 (Test Methods for Water Vapor Transmission of Materials)

Delivery Status

The majority of products are shipped in 3.5 and 5 gallon pails, 28 oz. cartridges, and 50 gallon drums.





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Base Materials / Ancillary Materials

Products in Tyvek® Fluid Applied WB Systems are based on proprietary polymer technology. Formula variations between components is small; therefore an average composition (Table 2) was used for all four products in the system.

Table 2: Fluid applied material composition in mass percent

Material	System average	Weather Barrier	Flashing & Joint Compound	Sealant	Flashing – Brush
Proprietary polymer	41%	25 - 50%	25 - 50%	20 - 30%	25 - 50%
Limestone	20%	15-25%	-	30 - 40%	-
Calcium carbonate (precipitate and non-precipitate)	16%	10 - 20%	20 - 30%	10 - 20%	20 - 30%
Polyether diol	10%	15 - 25%	15 - 25%	10 - 20%	15 - 25%
Titanium dioxide	6%	2-7%	5 - 10%	1 - 5%	5 - 10%
Diamino silane	3%	1 - 5%	1 - 5%	-	1 - 5%
Trimethoxyvinyl silane	2%	1 - 2%	1 - 2%	-	1 - 2%
Other	< 2%	0.01-2%	-	0.1-1%	-

No base or ancillary materials are included in the Resource Conservation and Recovery Act (RCRA). For more information on these products, visit the [DuPont™ Tyvek® Fluid Applied WB System website](#).

Manufacture

DuPont™ Tyvek® Fluid Applied WB System products are manufactured by mixing ingredients and packaging for shipment.

Environment and Health during Manufacturing

Where there is potential for airborne exposures in excess of applicable limits, wear NIOSH (National Institute for Occupational Safety and Health) approved respiratory protection. This material does not contain any chemical components with known CAS numbers that exceed the threshold reporting levels established by SARA Title III, Section 313. In this product, crystalline silica is not supplied in the form regulated in California and known to the State of California to cause cancer. PA Right to Know Regulated Chemical(s): titanium dioxide, limestone, calcium carbonate. Product complies with applicable federal, state/provincial and local regulations for waste disposal.

Product Processing/Installation

Tyvek® Fluid Applied WB System products may be sprayed, rolled or brush applied. Application using a pressure roller, such as a Graco Pressure Roller, is preferred.

Packaging

Tyvek® Fluid Applied WB System products are packaged in plastic buckets, drums and cartridges.





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Condition of Use

DuPont™ Tyvek® Fluid Applied WB should not be used for below grade applications or in applications in which it will be permanently exposed. It should be covered with the facade within nine months to limit UV exposure. Asphalt based adhesives are not recommended for use with this product.

Environment and Health during Use

Spray application could generate harmful vapor; apply in a well-ventilated area and use a NIOSH approved respirator.

Reference Service Life

No use stage modules are reported; as such, declaration of the reference service life (RSL) is voluntary. A RSL has not been declared for the Tyvek® Fluid Applied WB Systems.

Extraordinary Effects

Tyvek® Fluid Applied WB System products conform to the following standards pertaining to extraordinary effects:

Fire

- NFPA 285: Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components

Water

- AATCC-127, Hydrostatic Head Test for WRB measuring pressure to failure or time of failure at a given pressure; ASTM E331-2000, Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, And Curtain Walls by Uniform Static Pressure

Air Leakage Control

- ASTM E 2178-2008, Standard Test Method for Air Permeance of Building Materials; ASTM E 283-2004, Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen; ASTM E 2357-2011 Standard Test Method for Determining Air Leakage of Air Barrier Assemblies; ASTM E1677-2011, Standard Specification for Air Barrier (AB) Material or System for Low-Rise Framed Building Walls; ASTM E779-10 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization (whole building).
- See the Other Environmental Information section for building energy savings.

Re-use Phase

Fluid applied membrane products, by design, adhere to the underlying substrate; consequently, there is no possibility for reuse.

Disposal

Since Tyvek® Fluid Applied WB System products are not separated from general construction waste at end-of-life, they are assumed to be disposed to landfill.





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Life Cycle Assessment Calculation Rules

Declared Unit

The declared unit for Tyvek® Fluid Applied WB Systems is 1 square meter (m²). The complete weatherization system consists of weather barrier and flashing and flashing accessories, as well as self-adhered flashing product. Table 3 shows the reference flow of each component required for a base building.

Additional StraightFlash™ products to adjoin roof systems and below-grade water proofing are not considered in this analysis, nor are sealants for window installation.

Table 3: Product breakdown per declared unit

Component	Type of Sealing	Amount per declared unit [kg]	Surface density [kg/m ²]
Tyvek® Fluid Applied WB	Fluid applied	0.752	0.899
Tyvek® Fluid Applied F&J	Fluid applied	0.128	
DuPont™ Sealant	Fluid applied	0.0086	
StraightFlash™ 9”	Flashing	0.0098	

System Boundary

The analysis includes all modules in the production and installation stages (A1 – A5), along with the transport (C2) and disposal (C4) modules in the end-of-life stage. As such, it represents a “cradle to gate – with options” system boundary. Specific use stage impacts will vary substantially due to climate, building design, regional codes, energy fuel supplies, etc. Therefore, this stage of the life cycle (B1 - B7) is not included in the EPD. However, energy use during the use-stage can be significantly impacted by the reduction in air leakage rate available with the Fluid applied product system relative to alternative construction. An evaluation of a typical US based application for the use stage operational energy use (B6) is presented in the Other Environmental Information section of this EPD.

Table 4: System boundary

Production			Installation		Use stage							End-of-Life			Next product system	
Raw material supply	Transport to manufacturer	Manufacturing	Transport to building site	Installation into building	Use / application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to end-of-life	Waste processing for reuse, recovery or recycling	Disposal	Reuse, recovery or recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	X	MND	X	MND

X = declared module; MND = module not declared





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Estimates and Assumptions

The complete weatherization system consists of fluid-applied weather barrier membrane, flashing, and flashing accessories, as well as self-adhered flashing product. A reference flow was estimated using a representative building, "Hotel, Small" prototype (Pacific Northwest National Laboratory, 2015), to determine the relative amounts required of each product. Once the masses of each product needed to seal the representative building were calculated, the numbers were scaled down to the functional unit of 1 m² using the building's exterior wall surface area of 1,640 m². Total reference flow for the representative building was calculated to be 0.899 kg per m².

Production of the fluid applied weather barrier is based on a confidential proprietary polymer technology and was modeled using a polyether polyol dataset from the GaBi 2016 database as a proxy.

Primary data for the production of 9" StraightFlash™ were not collected since the mass of this component represents approximately 1% of total declared unit mass. Instead, proxy data were used to represent the Tyvek® StraightFlash™ top sheet and butyl adhesive based on product composition.

EPD results omit use-stage impacts, which includes indirect energy consumption—that is, the share of a building's operational energy consumption that can be causally attributed to the weatherization system. Given that most energy associated with a building's life cycle is consumed during its operation, indirect energy consumption for the weatherization system is expected to represent a large fraction of the product's cradle-to-grave environmental burden. This number, however, is also difficult to quantify with reasonable effort or certainty. Therefore, a payback period approach is used to illustrate the effect application of DuPont's Tyvek® Fluid Applied Weather Barrier System can have on building operational energy consumption in the section Other Environmental Information. Users of this EPD are encouraged to consider Use-Stage impacts in the evaluation of Fluid Applied Weatherization product systems for specific applications.

Cut-off Criteria

No cut-off criteria were applied in this study. All reported data was incorporated and modeled using best available life cycle inventory (LCI) data.

Background Data

Background datasets for upstream and downstream data are representative of the years 2009 – 2015 and were obtained from the GaBi 2016 databases (thinkstep, 2016).

Data Quality

A variety of tests and checks were performed throughout the project to ensure high quality of the completed LCA. Checks included an extensive review of project-specific LCA models as well as the background data used.

Data included first-hand industry data from DuPont in combination with consistent background life cycle inventory information from the GaBi 2016 databases. The data are representative of DuPont™ Tyvek® Fluid Applied products produced in the United States in 2015.

Period under Review

Data are representative of manufacturing during 2015.



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Allocation

No allocation was necessary for primary data collected from DuPont’s manufacturing facility.

Comparability

A comparison or an evaluation of EPD results is only possible if all results to be compared were created using the same background data and according to the same guidelines, including EN 15804 (CEN, 2013) and the PCR (IBU, 2014). Additionally, the building context and product-specific performance characteristics should be taken into account. Further, use-stage functionality of the product should be considered, particularly air infiltration reduction potential, the potential to reduce building energy use relative to a baseline building design with no effective air leakage control, as well as the potential to increase levels of envelope leakage control established by common industry standards.

Life Cycle Assessment Scenarios and Additional Technical Information

Information relevant to the life cycle modules included in this study are summarized in the following tables.

Table 5: Transport to building site (A4)

Property	Value	Unit
Liters of fuel	39	L / 100 km
Transport distance	800	km
Capacity utilization (including empty runs)	78	%

Table 6: Installation at building site (A5)

Property	Value	Unit
Material loss	5	%
Packaging waste	0.072	kg
VOC emissions to air	0.019	kg

Table 7: End-of-life (C1-C4)

Property	Value	Unit
Collected as mixed construction waste	0.881	kg
Landfilling	0.881	kg





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Life Cycle Assessment Results

Results for 1 m² of installed Tyvek® Fluid Applied Weather Barrier Systems are presented below.

ENVIRONMENTAL IMPACTS							
CML 2001 (Apr 2013)							
Parameter	Unit	A1-A3	A4	A5	C2	C4	D
GWP	[kg CO ₂ eq.]	3.50E+00	5.83E-02	2.30E-01	2.14E-03	3.95E-02	-1.35E-03
ODP	[kg CFC-11 eq.]	3.57E-10	4.80E-13	3.62E-07	1.76E-14	7.56E-13	-4.08E-13
AP	[kg SO ₂ eq.]	9.61E-03	2.16E-04	6.48E-04	7.94E-06	1.71E-04	-3.56E-06
EP	[kg PO ₄ ³⁻ eq.]	1.17E-03	5.57E-05	1.12E-04	2.05E-06	2.18E-05	-2.28E-07
POCP	[kg C ₂ H ₄ eq.]	1.19E-03	2.57E-05	6.92E-03	9.46E-07	1.73E-05	-2.32E-07
ADPE	[kg Sb eq.]	1.53E-05	8.72E-09	7.81E-07	3.21E-10	1.51E-08	-2.44E-10
ADPF	[MJ]	6.64E+01	8.19E-01	4.29E+00	3.01E-02	5.97E-01	-1.60E-02
TRACI 2.1							
Parameter	Unit	A1-A3	A4	A5	C2	C4	D
GWP	[kg CO ₂ eq.]	3.50E+00	5.83E-02	2.30E-01	2.14E-03	3.95E-02	-1.35E-03
ODP	[kg CFC-11 eq.]	3.80E-10	5.10E-13	3.62E-07	1.88E-14	8.04E-13	-4.34E-13
AP	[kg SO ₂ eq.]	9.96E-03	2.83E-04	7.46E-04	1.04E-05	1.84E-04	-3.39E-06
EP	[kg N eq.]	9.74E-04	2.63E-05	8.78E-05	9.67E-07	1.02E-05	-1.57E-07
SFP	[kg O ₃ eq.]	1.48E-01	8.99E-03	6.19E-02	3.31E-04	3.58E-03	-3.38E-05

GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources; SFP = Smog formation potential

RESOURCE USE							
Parameter	Unit	A1-A3	A4	A5	C2	C4	D
PERE	[MJ]	3.46E+00	1.36E-02	1.94E-01	5.01E-04	3.88E-02	-1.28E-03
PERM	[MJ]	2.68E-01	-	1.34E-02	-	-	-
PERT	[MJ]	3.73E+00	1.36E-02	2.07E-01	5.01E-04	3.88E-02	-1.28E-03
PENRE	[MJ]	5.19E+01	8.23E-01	3.31E+00	3.03E-02	6.13E-01	-1.96E-02
PENRM	[MJ]	1.81E+01	-	1.18E+00	-	-	-
PENRT	[MJ]	7.00E+01	8.23E-01	4.50E+00	3.03E-02	6.13E-01	-1.96E-02
SM	[kg]	-	-	-	-	-	-
RSF	[MJ]	-	-	-	-	-	-
NRSF	[MJ]	-	-	-	-	-	-
FW	[m ³]	4.87E+01	1.67E-01	2.59E+00	6.14E-03	9.43E-02	-5.85E-03

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

OUTPUT FLOWS AND WASTE CATEGORIES							
Parameter	Unit	A1-A3	A4	A5	C2	C4	D
HWD	[kg]	6.12E-08	1.05E-09	4.09E-09	3.85E-11	1.17E-09	6.12E-08
NHWD	[kg]	4.36E+01	1.04E+00	2.66E+00	3.84E-02	6.28E-01	4.36E+01
RWD	[kg]	1.43E-03	1.73E-06	8.11E-05	6.37E-08	6.23E-06	1.43E-03
CRU	[kg]	-	-	-	-	-	-
MFR	[kg]	-	-	-	-	-	-
MER	[kg]	-	-	-	-	-	-
EEE	[MJ]	-	-	6.20E-03	-	-	-
EET	[MJ]	-	-	2.92E-03	-	-	-

HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy





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Interpretation

The results represent the cradle-to-gate and end-of-life environmental performance of Tyvek® Fluid Applied WB Systems. For most impact categories, the manufacturing stage (modules A1-A3) is the dominant contributor to life cycle impact, with the exception of ozone depletion and photochemical ozone creation results. Potential ozone depletion impact is almost entirely due to chloromethane (a.k.a. methyl chloride) emissions as this material is used as a solvent in butyl adhesive production (for the StraightFlash™). Fugitive NMVOC (non-methane volatile organic compound) emissions from the fluid applied products are a key contributor to potential photochemical ozone creation impact. Emissions during installation also contribute to smog formation potential (TRACI 2.1), but manufacturing is still a key contributor to this metric due to differences in impact models—specifically, due to differences in characterization factors for unspecified NMVOCs and nitrogen oxides. Disposal (module C4) has a relatively small impact across all environmental indicators.

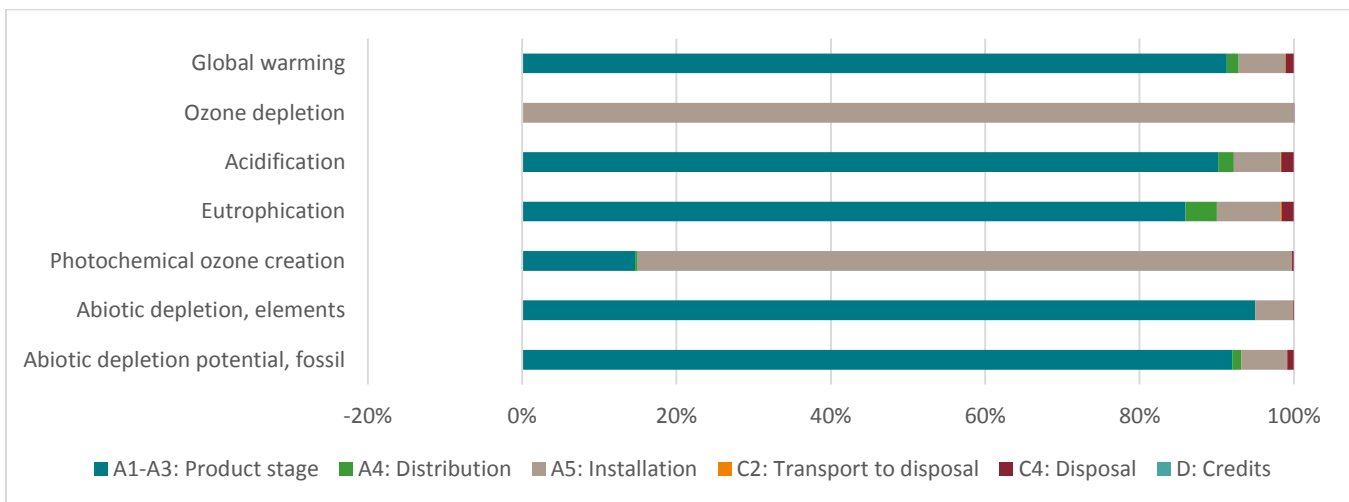


Figure 1: CML 2001 (April 2013) impact category results

Requisite Evidence

No requisite evidence is required for Tyvek® Fluid Applied WB Systems.

Other Environmental Information

Building Use Stage Benefits

The EPD analysis focuses on the production, distribution, installation, and disposal of the Tyvek® Fluid Applied Weather Barrier System. However, it does not provide a complete picture of the overall environmental impact associated with the weatherization system as it omits the building use stage. While DuPont™ Tyvek® Fluid Applied Weather Barrier Systems itself does not consume energy, its use can reduce building air leakage rate, which in turn





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lowers building energy consumption required for space heating and cooling. The extent to which weather barrier use reduces building energy consumption can exceed the energy needed to manufacture, install, and dispose the barrier. Therefore, use of the weather barrier to reduce air leakage rates can have a net positive effect on a building’s environmental footprint.

A payback period approach is used to compare the upfront “energy cost” of that DuPont™ Tyvek® Fluid Applied Weather Barrier System with the “energy savings” due to reduction in building operational energy consumption. A U.S. average case is used to estimate the time needed to “payback” the energy and greenhouse gas impacts associated with manufacturing, distributing, installing and disposing of the product system. For payback times shorter than the building service life, the use of a weather barrier system would result in net impact reductions in the building’s environmental footprint relative to a baseline option without such a system.

Since energy requirements will vary based on numerous factors, including building design, regional weather, temperature control systems, building heating and cooling sources, code requirements, etc. the calculations are performed for a U.S. average case, using average energy savings across all climates for a representative building. The “Hotel, Small” prototype or a similar building is used as a representative building to estimate space heating and cooling energy savings, as well as to calculate weatherization system energy demand.

The small hotel characteristics are shown in Table 8. Based on these characteristics, 1,640 m² of weatherization system are required to seal the building envelope. This is associated with a total primary energy demand of **131 GJ** (= 79.9 MJ/m² × 1,640 m²).

Table 8: Small hotel building characteristics

Property	Value (Imperial)	Value (metric)
Building height	38 ft.	11.6 m
Number of stories	4	4
Floor space	43,200 ft. ²	4,010 m ²
Exterior wall area (covered by membrane system)	17,700 ft. ²	1,640 m ²

Estimating reduction in space heating and cooling energy consumption associated with reduction in air leakage is somewhat more complicated due to lack of data and appropriate guidelines for air infiltration input into whole-building energy simulation models. An overview of the calculation approach is as follows:

- 1) Define air leakage rates for a baseline building and an airtight building as would be the case for a building using the Tyvek® Fluid Applied Weather Barrier system.
- 2) Using whole building energy simulations, calculate percent energy savings for an average commercial building, based on meeting different air leakage rates defined in (1).
- 3) Translate percent energy savings to an absolute value based on commercial sector annual energy consumption for space heating and cooling. Use U.S. average data for building design, climatic assumptions, and fuel supply for both heating and cooling systems.
- 4) Calculate energy savings per 1,000 square feet of building floor space based on total floor space for the commercial sector.
- 5) Calculate energy savings for the representative building based on results from (4) and building floor area from Table 8.
- 6) Energy savings for the representative building can then be compared with the weatherization system energy demand to calculate the energy payback period.





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7) A similar methodology is used to calculate the “payback” period for greenhouse gas

These calculations are briefly summarized below.

(1) The following air leakage rates were used for this analysis:

- *Baseline building:* **1.00 CFM/SF @ 75Pa** (0.3 in. w.c.) based on whole building tests of existing buildings, measured as part of USACE (US Army Corps of Engineers) air barrier program
- *Airtight building:* two different standards were used: **0.40 CFM/SF @ 75Pa** (0.3 in. w.c.) based on ASHRAE 90.1-2013 Appendix G, and **0.25 CFM/SF @ 75Pa** (0.3 in. w.c.) based on USACE requirements.

It is possible to achieve Whole Building air tightness using the Tyvek® Fluid Applied Weather Barrier system that exceeds the 0.25 CFM/SF @ 75 Pa standard. If a whole building airtightness test results are available for a given building, the actual value could be used in the energy model to calculate the energy savings for a specific project.

(2) Whole building energy simulation data from (Zhivov, 2013) provides percent energy savings for the two air leakage rates 0.25 CFM/SF and 0.4 CFM/SF as compared to a baseline air leakage rate of 1.0 CFM/SF (all measured at 75 Pa). This information is then combined with building construction volume for each ASHRAE climate zone (Jarnagin & Bandyopadhyay, 2010) in order to calculate weighted average energy savings across all climate zones (shown in Table 9, second column).

Table 9: Annual primary energy consumption and energy savings for ALL US commercial buildings

Air tightness standard @ 75 Pa	Weighted % energy savings	Commercial energy end use for space heating & cooling [10 ¹⁵ Btu]		Commercial energy savings for space heating and cooling [10 ¹⁵ Btu]	
		2010 primary	2015 primary	2010 primary	2015 primary
1.0 CFM/SF	0% (baseline)	5.77	4.13	0	0
0.4 CFM/SF	6.5%	5.77	4.13	0.38	0.27
0.25 CFM/SF	12.3%	5.77	4.13	0.71	0.51

(3) Next, total energy used for space heating and cooling for all commercial buildings was obtained from the 2011 Buildings Energy Data Book (US Department of Energy, 2012). Energy used for space heating and cooling was calculated based on commercial sector energy consumption in BEDB Table 3.1.3 and on percent of that energy used for space heating and cooling in BEDB Tables 3.1.4 and 3.1.5. Calculated percent energy savings was then applied to space heating and cooling energy consumption to calculate the amount of energy saved. Results based on BEDB 2010 calculations and 2015 projections are shown in Table 9.

(4) Commercial building primary energy savings associated with space heating and cooling from Table 9 are then divided by the total floor area of all commercial buildings (also from (US Department of Energy, 2012)) to calculate energy savings per 1,000 SF of floor space. These normalized results are shown in Table 10.





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Table 10: Annual energy savings for representative building

Air tightness standard @ 75 Pa	Floor space [10 ⁹ SF]		Commercial energy savings for space heating and cooling, normalized by floor area [MMBtu / 1,000 SF]		Representative building energy savings for space heating and cooling [MMBtu / yr.]	
	2010	2015	2010 primary	2015 primary	2010 primary	2015 primary
1.0 CFM/SF	81.1	84.1	0	0	0	0
0.4 CFM/SF	81.1	84.1	4.6	3.2	200	140
0.25 CFM/SF	81.1	84.1	8.8	6.0	380	260

(5) Finally, energy savings associated with the representative building are calculated based on the representative building’s floor space in Table 8. The results are shown in the last two columns in Table 10 for 2010 and 2015.

(6) Energy payback period is calculated based on the weatherization system energy demand as it compares to annual energy savings from Table 10. Results in Table 11 indicate that payback period is on the order of months. Therefore, most of the energy required to manufacture, install, and dispose DuPont™ Tyvek® Fluid Applied Weather Barrier Systems is recovered within the first year of building use due to lower space heating and cooling energy consumption.

Table 11: Energy payback period calculation for small hotel building prototype

Air tightness standard @ 75 Pa	Product energy demand [MJ]	Weighted % energy savings	2010 building energy savings	2010 payback period	2015 building energy savings	2015 payback period
1.0 CFM/SF	0	0% (baseline)	0 GJ	N/A	0 GJ	N/A
0.4 CFM/SF	131 GJ	6.5%	210 GJ	7.5 months	150 GJ	11 months
0.25 CFM/SF	131 GJ	12.3%	400 GJ	3.9 months	270 GJ	5.7 months

(7) Likewise, global warming potential payback period can be calculated using the same methodology (since energy savings lead to greenhouse gas emissions reduction) and the results are summarized in Table 12. Total CO₂ emissions used to calculate payback period were obtained from Tables 3.4.2 and 3.4.3 in the Building Energy Data Book (US Department of Energy, 2012).

Table 12: Global warming payback period calculation for small hotel building prototype

Air tightness standard @ 75 Pa	Product carbon emissions [kg CO ₂ e]	Weighted % energy savings	2010 building GWP reduction [kg CO ₂ e / yr.]	2010 payback period	2015 building GWP reduction [kg CO ₂ e / yr.]	2015 payback period
1.0 CFM/SF	0	0% (baseline)	0	N/A	0	N/A
0.4 CFM/SF	6,280	6.5%	10,800	7.0 months	7,300	10 months
0.25 CFM/SF	6,280	12.3%	20,300	3.7 months	13,800	5.5 months

The potential global warming impact during manufacture, installation, and disposal of DuPont’s Tyvek® Fluid Applied Weather Barrier Systems is “recovered” within the first year of building use due to lower space heating and cooling energy consumption. Since energy savings and global warming potential reduction from building envelope airtightness





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are expected throughout the building service life (typically > 50 years), Tyvek® Fluid Applied WB Systems are anticipated to have a net environmental benefit over the remaining of the building life.

Other Air and Water Barrier Benefits

In addition to energy savings which were quantified in this analysis through whole building energy simulations, Tyvek® systems provide substantial additional benefits by preventing risks associated with water intrusion and air infiltration. Potential risks associated with water intrusion can range from health risks (due to mold and dampness which could affect the IEQ), to building envelope durability/materials degradation (such as rotting of wood or corrosion of metals), to materials performance (such as loss of insulation R-value). Potential risks associated with air infiltration include impact on the occupant's comfort (e.g. cold drafts) and transport of outdoor contaminants into the conditioned space, affecting the IEQ. A continuous WRB system is a cost-effective measure for avoiding risks associated with water intrusion and air infiltration. While these additional WRB benefits are more difficult to quantify because moisture intrusion and air infiltration events are unpredictable, the impact on building envelope durability/longer building life (which will obviously impact materials resources), as well as comfort and health of the building occupants could be significant.

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